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[625 .258 (.44) & 656 .259 (.44)]

Appliances for braking wagons in marshalling yards controlled from a distance, (1)

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Figs. 1 to 5, pp. 6 and 8.

We think it will be of interest to report where our two years practical experience has taken us, and what have been the results obtained with our distant operated braking gear in the marshalling yard at Bordeaux-Saint-Jean.

First of all, it must be pointed out that the single arrangement with only one skid on one rail (fig. 5 of the article published in December 1926) has been given up, so far as the braking device, properly speaking, is concerned. It has been replaced by the double brake shewn in figure 1. The single brake is only retained in the special cases that will be mentioned later.

This decision was based on the unanimous opinion of the brakesmen at the box and in the sidings, and also on the results of our observations and tests.

As from June 1926 one of the roads of the fan provided with brakes (siding No. 8) was fitted, in line with the sleepers marking the usable limit of the sidings, with two double brakes spaced 1.50 m. (4 ft. 11 in.) apart.

This siding being on a curve, the first brake allowed wagons to be braked a distance of 6.50 m. (21 ft. 4 in.), and the second a length of only 4.50 m. (14 ft. 9 in.) (fig. 2).

After six months' test, the brakesmen reported that with the arrangement fitted on No. 8 siding they could regulate as desired the speed of the wagons so as to avoid rough shunts, and that they thought all the sidings should be so fitted.

Furthermore, our daily observations had shewn that the single brake withdrew the skid from under the wheel too soon. This resulted from the fact that braking with a single skid did not at once stop the wheel from rotating; the wheels turned round in almost all cases the whole time they were being braked.

Under these conditions, the motor, put

(1) See *Bulletin of the Railway Congress*, December 1926 number, p. 1063.

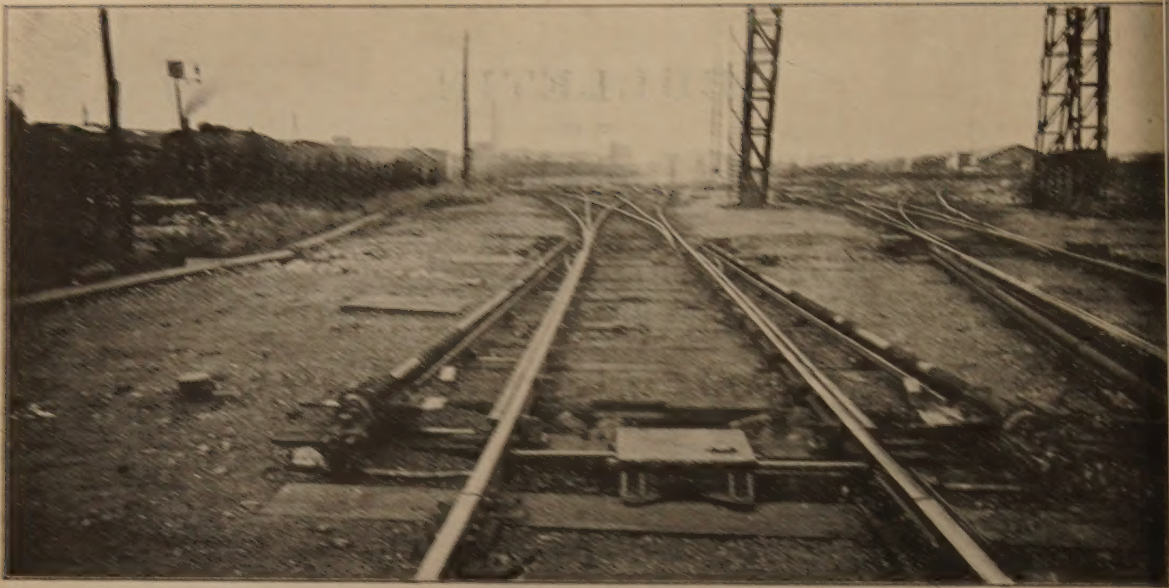

Fig. 1.

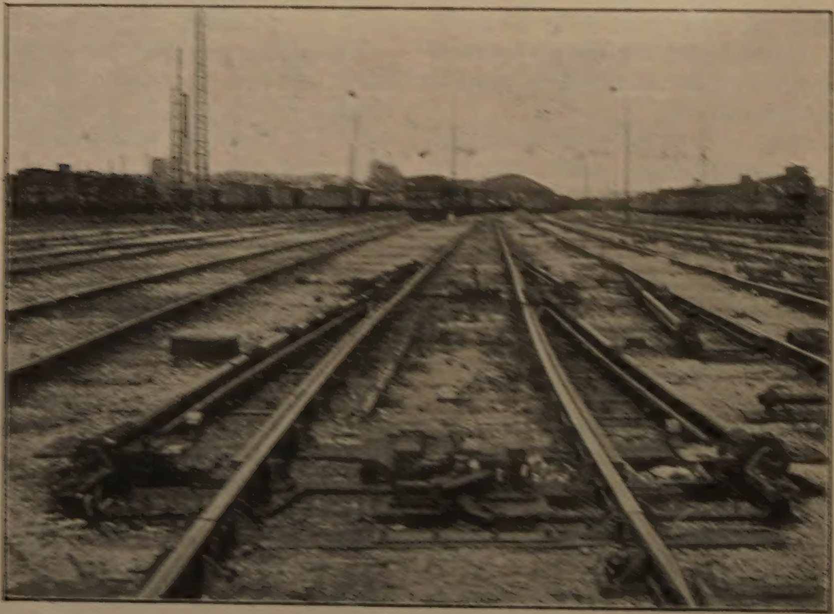

Fig. 2.

into circuit by the action of the withdrawing commutator, freed the skid before this latter had been carried to the end of its travel.

The uncompleted travel of the skid resulted in the compression of the springs being reduced : consequently, these latter in releasing, were unable to give sufficient force to return the skids to the starting point.

With the double brake, this disadvantage does not exist, as the axle stops turning as soon as each wheel runs on to a skid. The skids, under the weight they carry, can only be released by the action of the skid remover, the compression of the springs is properly assured by the skids reaching the end of their travel and the return of the skids takes place correctly.

The Rolling Stock Service, which is interested in maintaining the wagons in proper condition, has reported definitely in favour of the double brake.

The single brake, by the reaction it gives rise to, causes the wagon to wedge itself in the track : this starts or increases the twisting of the wagon frame (fig. 3): succeeding brakings on the right and on the left increase the twisting and loosen the fastenings [1].

Braking symmetrically on the two wheels avoids these defects or reduces them considerably in the event of two skids not being returned exactly to the same place.

We have just shewn that with the double brake the skids are returned under better conditions than with the single brake. This is of great importance, as it is essential that the brakesman at the box can always count, to within a few centimetres, on the same braking length with each brake.

It is most unusual with the single brakes we have in use, when kept in good repair and well lubricated, for the skid not to return to its starting point. It is none the less certain that with the double brake the failures have been halved : this leads us to say that, in all cases, axles first coming on to a double brake find at least one skid properly placed so that the total braking power of the brake can be utilised.

It is of course easy with a single brake to ensure that the skid returns to its starting point : for this it is sufficient to provide a distance *ab* long enough for the compression of as many springs as when released will almost completely fill the rod guiding them (fig. 4).

An arrangement of this kind has the advantage that the springs have less work to do in returning the skid to the starting point : it is then possible to reduce the amount of compression, the stress in the springs and increase their life thereby.

Tests made under such conditions have given complete satisfaction, and we have decided to take this arrangement into account when equipping all the sidings of the yard.

We thought it well to see if a brake of very considerable length would give any valuable results. With this object in view, we installed a brake capable of usefully braking for a length of 11 m. (36 ft. 1 in.). This brake is shewn in figure 5. To avoid the tube guiding the springs bending, three supporting flanges were fitted between the groups of springs.

The results obtained are summed up below :

1. The brake is very powerful : the

(1) One effect of this twisting is very visible when the top of a covered wagon which has run some time is examined. The canvas covering it creases diagonally as soon as a wheel comes in contact with a skid.

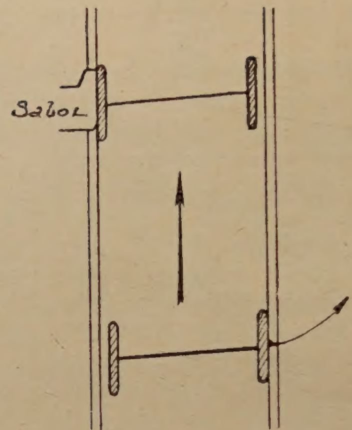

Fig. 3.

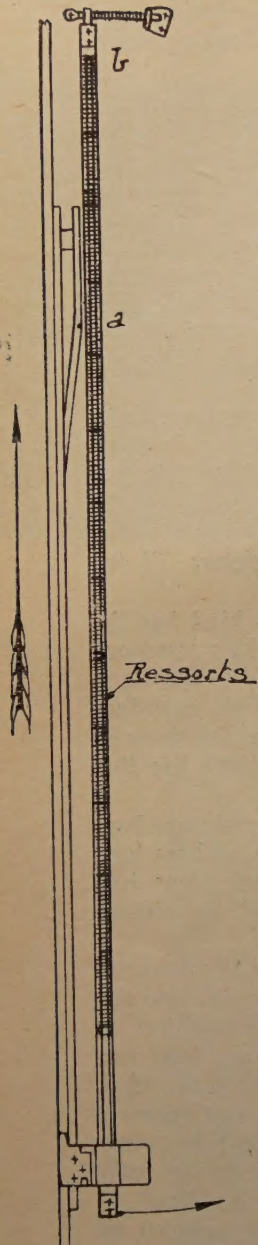

Fig. 4.

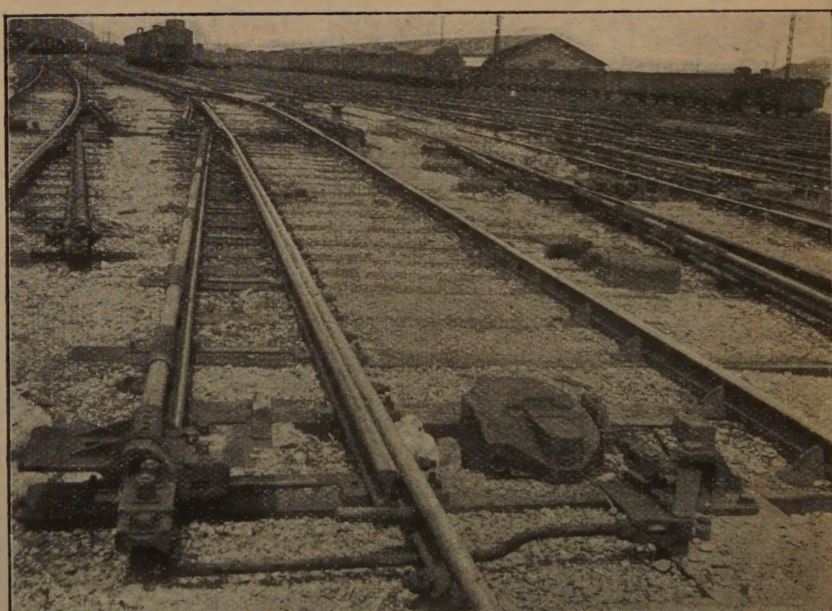

Fig. 5.

Explanation of French terms in figures 3 and 4: Ressorts = Springs. — Sabot = Skid.

brakesmen only use it to brake individual heavily loaded wagons or rakes of wagons;

2. Owing to the very great reduction in speed of the wagon, the withdrawal of the skids at the end of the travel occurs after the springs are properly compressed and the return of the skid to its starting point is made certain;

3. This slowing down results in a very soft action of the brake when the skid is withdrawn, and the parts affected (spring guides, skids) remain in good order;

4. As a result of the large number of springs utilised and of the withdrawal being made to take place beyond the skid withdrawer, the springs, for the reasons given previously, work under good conditions.

In fact, the length of the brake does not adversely affect its proper working, but just the contrary, and in special cases its use can be considered without hesitation.

Naturally, this brake has the defects already pointed out of the single short brakes, as regards twisting the wagon frames.

We have already said we are retaining some single brakes : those forming the intermediate group placed between the top group of brakes used to reduce the speed from the increased height given to the hump and the group of brakes placed in line with the limiting sleepers of the siding which form the effective set of brakes.

The intermediate group is chiefly used only to prevent side-on collision on the brakes directly controlling the entrance into the fan sidings. The single brakes being cheaper than the double, it appeared useless to convert them to double brakes in view of the role assigned them.

It may also occur that owing to the little space available where the sidings branch off, double brakes cannot be placed side by side. In such a case a single brake has to be used.

In our yards, this case has not arisen.

It should be noted that the cost of the double brake is not twice that of the single : in one as in the other, there is only one motor, and the length of the sleepers is sensibly the same. If a single brake cost 10 000 fr. for example, a double brake of the same braking length will cost 16 000 fr.

As regards brake power, it would be wrong to think that the double brake has twice the power of a single.

Tests have shewn that on the average for two brakes of the same braking length, the double brake absorbs 53.6 % of the momentum of the wagon, and the single 46 %.

This small difference is due to the result of braking with a single skid twisting the wagon frame and causing the wagon to wedge itself in the track : the braking is obtained at the expense of the wagon. This cannot be otherwise when braking by hand, as the brakesman cannot place at once two skids on the same rail : almost all mechanical devices for braking wagons proposed or in use provide symmetrical braking of both wheels of an axle.

It seems reasonable that the skid brake operated at a distance should conform with the same ideas.

This in no way detracts anything from its advantage, as the two skids can be placed on the rail or removed with equal facility, and successive brakings under a passing rake of wagons are assured in the same conditions : it only requires a more powerful motor.

A complete equipment for the marshal-

ling yard at Bordeaux (thirty sidings) has been decided upon, the following considerations being taken into account :

Account having been taken of the results obtained on the sidings fitted, a saving can be expected for the whole fan of sidings of 280 000 francs a year for staff and 15 000 francs for shunting engine.

Laying in the brakes enabled the hump to be given an increased height of 50 cm. (1 ft. 7 11/16 in.) and to ensure by gravity only, during cold weather, the crossings being cleared. This resulted in a saving of day labourers' wages of 30 000 fr. Furthermore, the speed of shunting the wagons increased from 4 to 6 a minute.

As regards regularity in braking, from counts made the number of cases of rough shunting averages 1.8 a month, for each siding fitted, against 3.3 for those not fitted. The violence of the shock is also less.

It must be noted that, when making the counts, the first group of brakes and those at the limiting sleepers of the sidings were single : with the present double brakes the position has still further improved.

This reduction in the number of rough shunts shews itself in a saving difficult to value on the claims paid for damage, but undoubtedly large. In addition, the cost of wagon repairs will be lower.

Finally, the reduction in the number of brakesmen lessens proportionately the risks of accidents to the staff. The work of those retained is less dangerous because the wagons that they have to brake occasionally will have a lower speed than those they had to stop formerly.

We thought we ought to bring the preceding notes to the notice of those interested in the question of the braking of wagons in marshalling yards.

July 1927.

[625 .143.3 & 625 .212]

The wear of tyres and rails,

By E. GUIRAUD,

ENGINEER : ARTS AND MANUFACTURES.

Figs. 1 to 3, p. 12 to 15.

(*Les Chemins de fer et les Tramways.*)

The marked increase in passenger traffic in and near large cities during recent years has raised in the minds of the railway engineers, in an increasingly disquieting way, the question of the wear of tyres and rails.

Without taking into account the very heavy cost of replacing the permanent way, the relaying of sections with heavy traffic is very difficult to carry out and interferes with the working of the line.

It will be realised therefore that everything has been done to reduce rail wear on such sections so that the renewal can be deferred to as widely separated periods as possible.

The wear of rails and tyres is primarily a metallurgical question Undoubtedly everything else being equal, improving the quality of the steels used will bring about a reduction in the physical and internal changes caused by the rolling action, both as regards the rails and the tyres, and reduce their wear to a certain extent : whatever the nature of such steels may be, use has demonstrated that on lines on curves, especially when of small radius, the rails and tyres wear in a way that makes it necessary to replace them much more frequently than is the case on lines with straight track only.

On the straight, the double coning of the two tyres in relation to the rolling surface, theoretically ensures the correct guiding of the axles without the flanges coming into action.

On curves, either because of difficulties in getting the stock to curve properly, or because of excessive superelevation as regards trains running below the maximum speed for which the superelevation was designed, or by the traction action of the locomotive which tends to cause the vehicles to be drawn towards the chord of the arc of the curve occupied by the train, the flanges do come up against the inside face of the head of the corresponding rail and with more or less pressure.

Referring to figure 1 below, shewing the section of a tyre and the corresponding rail on the vertical plane through the centre of the axle, it will be seen that the surface of contact *ab* of the flange and the rail which at each moment comes into action to limit the displacement of the axle towards the outside, is situated outside the cone of rolling of the wheel in question. This face, considered on the flange, therefore, describes a simple path the development of which is greater than corresponding displacements occurring simultaneously on the contact surface under consideration on the rail.

The two surfaces above are therefore, as a result of this fact, the seat of rubbing slip which causes them to wear quickly

so that the rail and tyre each after a certain time become worn to the shape shewn by 1, 2, 3 and 4, 5, 6, in dotted lines on figure 1.

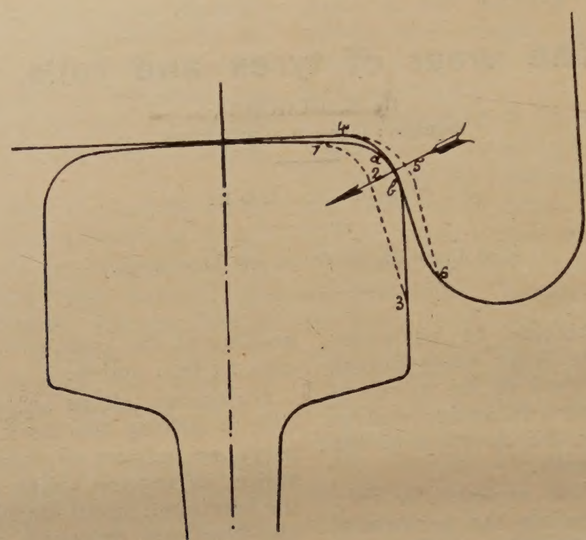

Fig. 1.

In addition to the wear of the tyre and the inside face of the rail head, there is on the line of rail on the inside of the curve, the wear due to the slip of the rolling surface of the wheel previously dealt with on the top of the rail.

A wheel moving on the outside rail completes a greater distance than the other wheel on the same axle : it causes the latter to turn more quickly than it would otherwise, so that its tyre slips on the rail causing a kind of milling action on the rail, which also wears at the same time the conical surface of the wheel.

The wear which we have just described is necessarily for a given line on a curve a function of the wheel loads, and of the coefficient of friction of the surfaces subjected to slip, so that there is obviously every interest in reducing this coefficient as much as possible by lubrication.

In practice the occasional oiling of rails by hand along curves of small radius has already reduced to a very large extent this wear, but where the traffic is very frequent this oiling to be of any use ought to be done very often and would entail rather high labour costs.

Some companies have made tests with automatic oilers fitted on curves.

The oiler consists of a sort of brush operated mechanically by a pedal worked by the wheels running over it, which, during the oscillating movement thereby given, takes oil from a container provided for the purpose and then applies it to the wheels.

In this form of construction the method is, in our opinion, not satisfactory, as the lubricant cannot rationally be applied by such means uniformly at the places where it would be most useful.

In order to get satisfactory results, it is necessary to use too much oil or grease, the bulk of which is wasted.

The method of using flange lubricators on the vehicles is undoubtedly the most rational as, with a minimum of lubricant, it enables the parts of the surface of the

tyre, and indirectly that of the rail subjected to the effects of slipping, to be lubricated.

A flange lubricator should have the following features :

1. Consume a minimum of oil;

2. Stop the feed of oil during stops without the driver having to take any action;

3. Retain its setting and require no attention other than the periodical replenishment of the oil.

These features are all found in an ingenious oiler designed and made by Mr. Buclon.

The remarkable results obtained immediately the tests started, to which we will return later, shewed very clearly the advantages to be expected from the oiling of flanges.

A general view of Mr. Buclon's oiler is shewn in figures 2 and 3, mounted in place on a carriage wheel.

It shows a main hollow body A which forms the oil reservoir.

This piece A is carried on the pin 16 on the ball bearing 11 — 19 so that A can turn at very high speed about this pin with little friction.

The bearing 11 ensures the radial and axial guiding of the body A : the bearing 19 only guides this part radially and allows for any expansion of the pin and the spacers of the bearings 17 without interfering with the rotation of A. In order to do this, the outer ring of the bearing 19 can slide without rocking inside the cylinder 24 cast with the main body A, thanks to the special spring 20 held in a circular groove 23, cut in the inside about half way up the cylinder 24.

The screw 21 locks the two bearings on the spacer 17. The bearing 11 is held on the end *a* of the body A by the screwed ring 10 which is prevented from slackening back by the circular spring 13 ending in a projection which locks the male and female screwed parts of the body and of the ring. After being put in place this spring lodges in the groove 12.

The pin 16 has an eye *c* which allows the apparatus to oscillate round the pin 4 of the fork ended rod which is threaded for adjustment and connects it to the bracket by which it is secured to the vehicle. A second joint D, with its pin parallel to the former, is provided between the bracket and the threaded end of the forked rod.

This second joint carries a regulating nut with a notched edge washer to set the angle by which, during erection, or in service, the inclination of the fork ended rod can be adjusted to set the apparatus in the correct position in regard to the tyre.

After setting, the joint is locked by tightening up the bolt of the bearing pin.

The lower part of the body A is hexagonal in shape, ending in a cup *i*, which has six oval openings *g* on its outer face. This part carries the leather washers B which, by means of a screwed ring with cap *f* are screwed up tightly against *i*.

The apparatus works as follows : the body A having been filled by the opening, 5, 6, the oil saturates the washers by openings *g* and, by capillarity, leaks onto the outside surface of the leathers, from which however it does not drip.

As soon as the vehicle moves, the leathers are driven by the rotation of the tyre and turn the cylindrical body about the axis of the apparatus at a speed in relation to that of the wheel in the ratio of the diameter of the wheel to that of the circle of contact of the bottom leather. This latter circle has a development of 0.35 m. to 0.40 m. (13 3/4 to 15 3/4 inches).

On a bogie wheel of a locomotive running at 60 km. (37.3 miles) an hour, the speed of rotation of the apparatus is about 2 600 revolutions a minute.

When running, the centrifugal force augments the feed of oil which becomes greater as the speed increases.

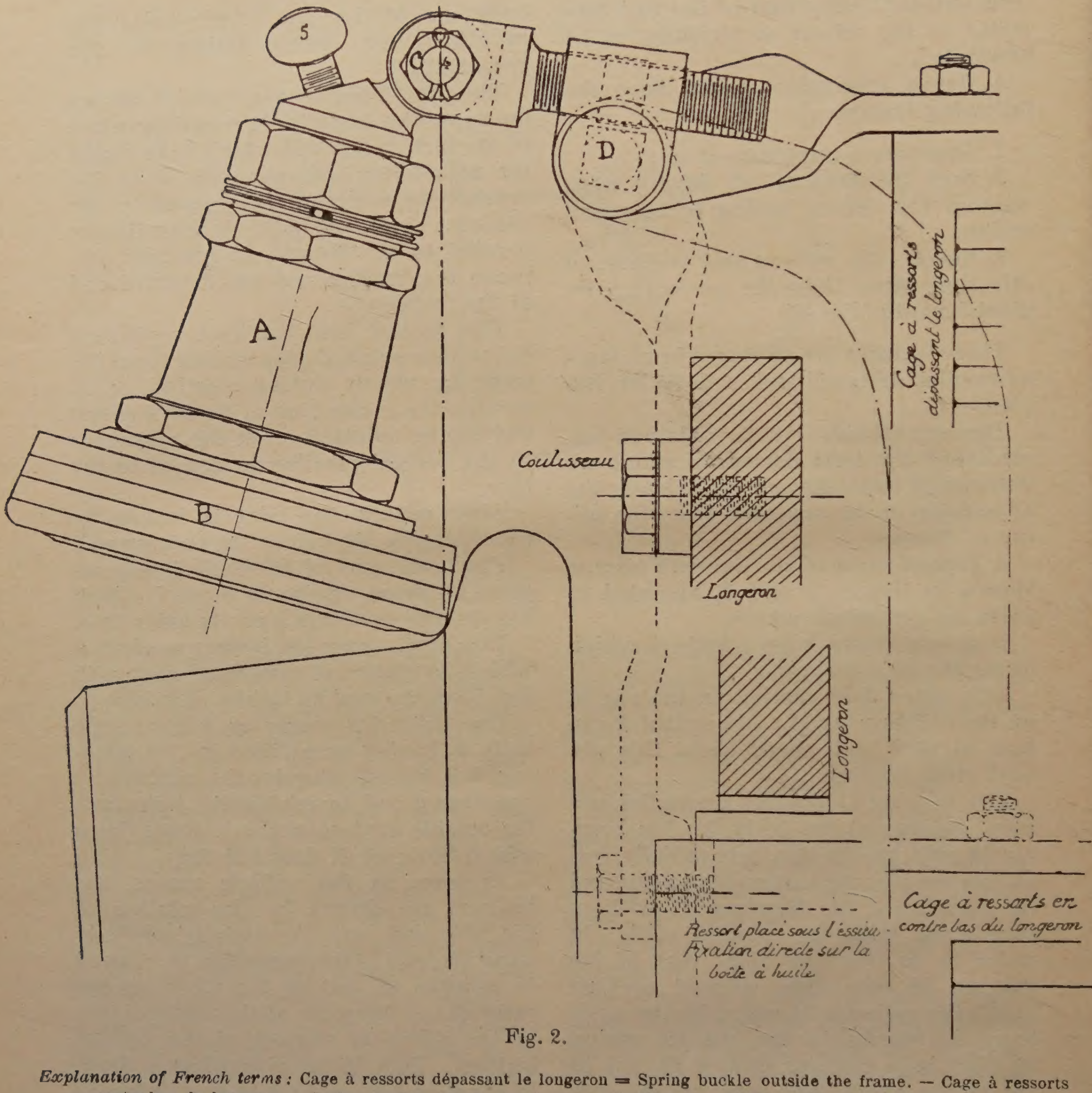

Fig. 2.

Explanation of French terms : Cage à ressorts dépassant le longeron = Spring buckle outside the frame. — Cage à ressorts en contre-bas du longeron = Spring buckle below the frame. — Coulisseau = Slide. — Fixation directe sur la boite à huile = Fastened direct to the oil box. — Longeron = Frame. — Ressort placé sous l'essieu = Spring placed below the axle.

The apparatus should be fitted as shewn in figure 2 in which the dotted lines indicate the different ways of erection met with in practice according to the type of vehicle to be fitted.

This figure shews that by adjusting the position of the pin of joint 4, the contact of the lowest leather can be made to coincide with the point on the radius of the flange most subject to wear according to the state and layout of the track run over.

In principle, when putting the apparatus in place, the point of contact, and the pin 4, should be set on the same vertical line so that during any lateral movement of the wheels the point of contact should move only a very little way along the profile of the tyre.

The point of attachment of the apparatus should be at a part of the vehicle having only small vertical movements; this is always possible, as if nothing better is available, the axle box, which always meets the above condition, itself can be used.

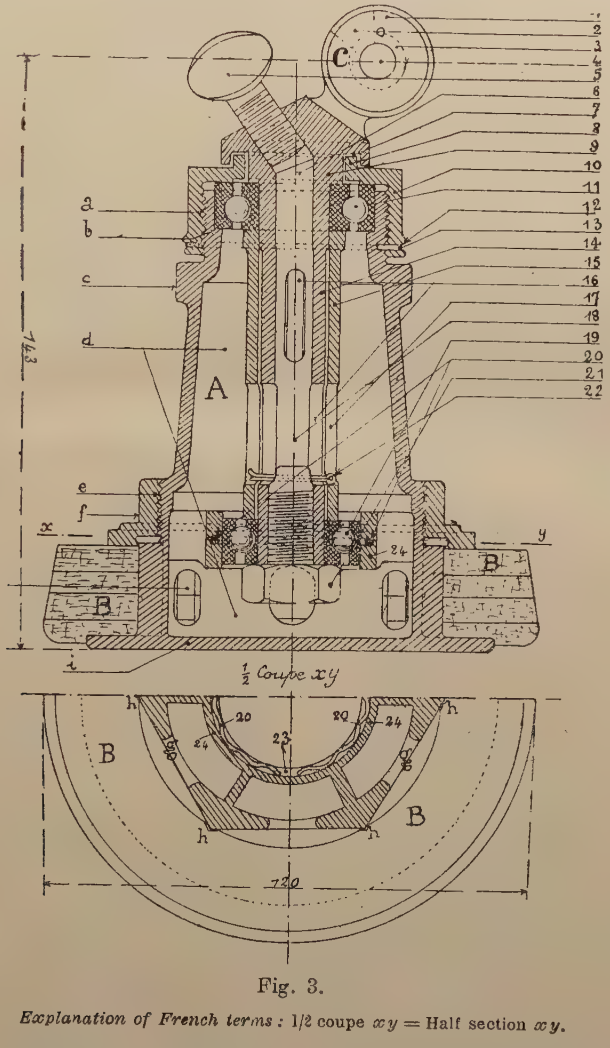

Fig. 3.

Explanation of French terms : 1/2 coupe xy = Half section xy.

As regards the oil to be used, the Buclon oiler requires filtered oils to prevent the leathers from becoming clogged up.

Experience has shewn that even on lines with many curves, only the two leading wheels of the bogie of each loco-

motive working over the line need be fitted with Buclon flange oilers to reduce the wear of the tyres in the locomotives and vehicles.

The oiling of the leading flanges lubricates the rails, and indirectly oils the following tyres.

It will be realised that the wear of the rails on small radius curves will be reduced in the same proportion as that of the tyres.

The Buclon oiler, which has only just been put on the market in its perfected form, has been well received by the railways having lines with many curves. Oilers have already been supplied to the Midi, Paris, Lyons and Mediterranean, and State Railways.

The price of the apparatus is very small in spite of the care with which it has been designed and manufactured, whereby it is practically free from wear in its main parts.

The Paris, Lyons and Mediterranean, and Midi Systems, having a large length of line in mountainous country, were the first in France to look for a means of overcoming the wear of tyres in curves of small radius : they have been much interested in the oiler made by Mr. Buclon.

Very complete tests of this oiler have been carried out by these two companies : the results obtained were very remarkable. On the line from Mende to La Bastide, a locomotive not fitted with oilers would not run more than 3 000 km. (1 860 miles) before the tyres and wheels required returning: when fitted with two Buclon oilers it ran 24 000 km. (14 900 miles) without the tyre wear exceeding the allowed limit before overhaul.

The comparative tests made on the Midi between Buclon oilers and flange oilers of a type used on that system for some time may be quoted. Two locomotives of the same type working the Carcassonne to Quillan line under practically the same conditions were fitted, one with Buclon oilers and the other with the old type oilers.

The test lasted 20 days. The number of kilometres run during this period was 2 046 (1 271 miles) for the first, with a total consumption of 1.200 kgr. (2.645 lb.) of oil, and 1 957 (1 216 miles) for the second with a consumption of 2.900 kgr. (6.393 lb.) of oil.

The wear of the tyres of the former locomotives was inappreciable by the usual methods of measurement, whilst the wear of the flanges of the second was 1.2 mm. (3/64 inch) measured a little above the plane of rolling.

These results shewed clearly the advantages to be got from the use of these oilers.

We cannot too strongly draw the attention of the various railway and tramway companies to the importance of this question of the lubrication of tyres of stock working over lines with small radius curves. It is incontestable at the present time that by flange oilers very important savings in the cost of upkeep of the stock and track can be effected and the running of trains improved, with consequently higher efficiency as regards their haulage.

[621 .133.5]

Developments in locomotive drafting, (1)

By Dr. W. F. GOSS,

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Figs. 1 to 3, pp. 18 and 20.

(From *The Railway Mechanical Engineer.*)

The turbo-exhauster.

A decision to proceed with the installation of mechanical draft in locomotive service at once opens the way for many different arrangements of details. I have preferred to work on an application of an exhaust-fan, directly connected with a steam turbine energized by the exhaust steam from the locomotive cylinders. The combination of turbine and fan, hereinafter referred to as the « turbo-exhauster », is a self-contained unit having a single shaft carrying a steam-turbine wheel at one end, and an exhaust-fan wheel at the other. The locomotive exhausts directly into the steam-supply header of the turbine, from which it passes through nozzles of appropriate size to the turbine wheel. The turbine takes all the exhaust from the locomotive cylinders, not a part of it. The nozzles of the turbine are the exhaust-tips of the new arrangement. The steam having done its work on the turbine-wheel is discharged into a casing which conveys it along the shaft of the turbo-exhauster to a point close to the back of the fan-wheel, where it flows in a steady stream into the front-end.

The course of the exhaust from the turbine wheel to the front-end is such that it maintains an atmosphere of exhaust steam about the journals and bearing of the turbo-exhauster and at the back of the exhaust-fan wheel. The pressure of this steam is merely the pressure of the front-end, and its temperature can never be higher than the temperature of steam at or below atmospheric pressure. This arrangement entirely disposes of any trouble which might otherwise be anticipated in maintaining journals and journal boxes within the front-end of a locomotive.

The turbo-exhauster has no valves or governors or other elements of control. All steam that the locomotive exhausts goes to the turbine wheel and the energy that it imparts to the turbine wheel is absorbed by the exhaust-fan wheel, so that the draft action induced by the turbo-exhauster responds to the volume of steam exhausted by the locomotive just as does the draft action in the presence of the open exhaust-jet now in use.

The exhaust of air pumps and of other steam auxiliaries is piped into the steam-header of the turbine, where it goes the same course as the exhaust from the locomotive cylinders. Experiments have shown that the exhaust from the air pump alone is quite sufficient to keep the turbo-exhauster in motion when the throttle of the locomotive is closed, so that on the road the turbo-exhauster never stops, though its speed may vary between very wide limits.

Quite independent of the steam-supply

(1) Abstract from a paper presented at the 8th annual meeting of the American Railway Association, Mechanical Division (Montreal, 7 to 10 June 1927). — See article on the same subject, in the May 1923 number of the *Bulletin of the Railway Congress*, p. 482.

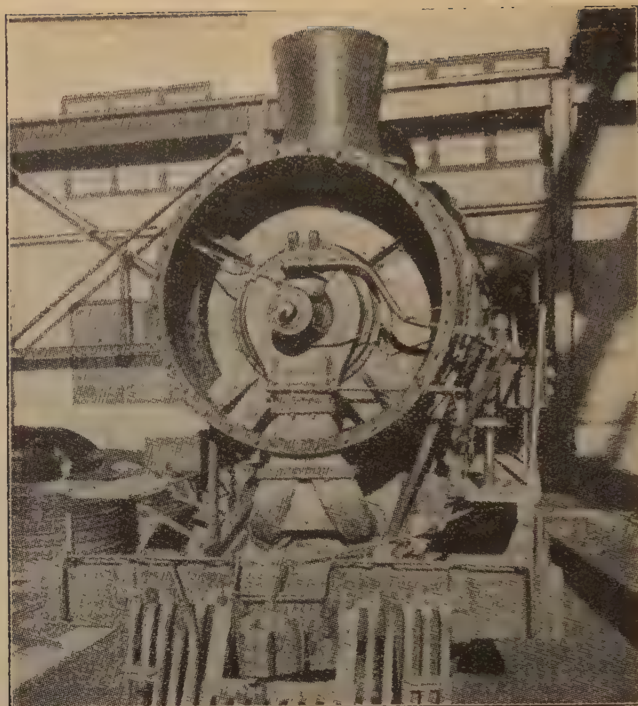

Fig. 1. — Turbo-exhauster in place,
showing steam connection between exhaust ports and turbo,
and blower-pipe connections for road experimentation

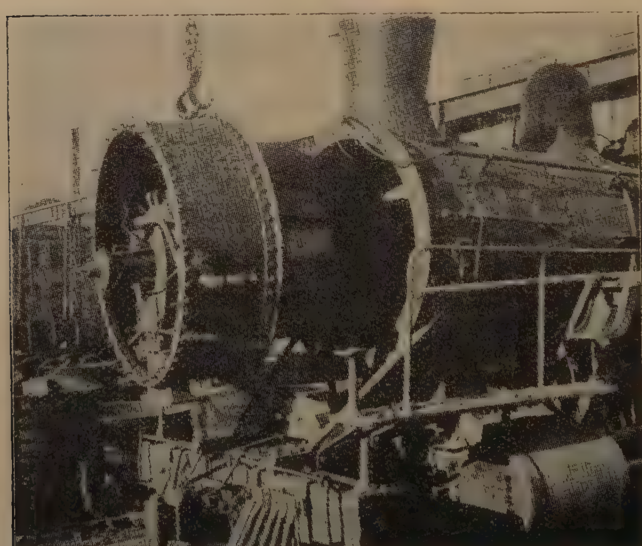

Fig. 2. — Turbo-exhauster in ring in process of application for experimentation.

All parts of the device go with the ring.

casing of the turbine is a small high-pressure steam header covering a nest of high-pressure nozzles arranged to act upon the turbine wheel. The usual blower pipe connects with this high-pressure header. In firing up, the round-house steam hose is attached to blower pipe, steam is turned on, and the turbo-exhauster, operating as a high-pressure steam turbine in quietness and efficiency not otherwise obtained, begins its work. The blower may be used as needed, not only when the throttle is closed but also on the road, when the throttle is open, and there is need of a real draft booster. The fact that the blower nozzles are independent of the exhaust nozzles permits them to be effective when worked either independently or in combination with the others.

The turbo-exhauster as a whole is arranged in the front-end immediately ahead of the superheater. Its shaft is parallel but not necessarily in line with the center line of boiler. In its application to existing locomotives it will often be found practicable to put it into existing front-ends, but the preferred arrangement is one which provides a short extension front-end ring within which all parts of the turbo-exhauster may be permanently installed. The stack is ordinarily moved forward to the new ring and the old stack-base sealed by a man-hole cover, by the removal of which, admission is given for inspection of superheater, and related parts. When a full exposure of the front-end is necessary, the supplement ring carrying out with it all parts of the turbo-exhauster is easily and quickly removed.

The turbo-exhauster presents no difficulties either of design or application arising from scientific considerations. Its fundamental details have all been analyzed and tested. Assuming that the functions it performs are desirable functions, its scientific soundness should insure its ultimate introduction.

The turbo-exhauster as a draft producer.

The efficiency of the turbo-exhauster as a producer of draft is the combined efficiency of the steam-turbine and the exhaust-fan. The steam-turbine is a device of comparatively high mechanical efficiency, but the conditions of service in the front-end of a locomotive are variable, and very high efficiency is not to be expected. In my initial study of the matter I assumed an efficiency of 60 % for the turbine. The exhaust-fan, with its cinder trap, is necessarily a fan of low efficiency, and I accepted for it an efficiency of 40 %. Under these estimates, the combined efficiency is 24 %; that is, the turbo-exhauster will return in useful draft effect substantially 25 % of the initial energy of the exhaust steam, which is to be compared with 8 % now obtained from the open exhaust-jet.

If we convert this increase in efficiency into reduction in back-pressure, by reference to a record of performance of the *Mikado* locomotive tested by Professor E. C. Schmidt, the facts are as follows :

Comparison of turbo-exhauster with normal locomotive.

Results of tests : normal locomotive.	Medium power.	Heavy power.
a) Lb. of coal per hour.	2 900.0	6 600.0
b) Lb. of steam per hour	23 000.0	42 000.0
c) Pressure of exhaust, lb.	2.0	12.0
d) Draft, inches of water	2.4	7.0
Results available by use of turbo-exhauster.		
e) Pressure of exhaust, lb.	0.85	3.4
f) Reduction in pressure exhaust, lb.	1.15	8.6
g) Reduction in pressure of exhaust, percentage of item *c*).	57.0	72.0

These values representing the possible performance of the turbo-exhauster as a draft producer are based upon an assumed performance of the turbine and fan. They have been confirmed in general terms by the performance of experimen-

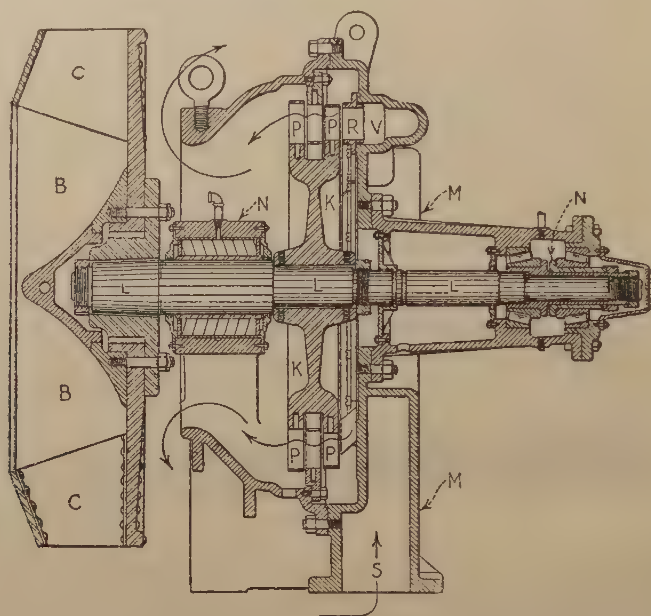

Fig. 3. — A vertical section of an experimental turbo-exhauster.

tal equipment in service on the road. It has been shown experimentally that the turbo-exhauster easily supplies all the draft needed, on a back-pressure which is less than half that now employed. Obviously there are great possibilities in this direction, which await the introduction of a more highly perfected design of turbine and fan.

Accepting for the present a reduction of 60 % in pressure of exhaust of our present day locomotive, it follows that the turbo-exhauster will save from 5 to 12 % of the steam now used, the precise amount depending upon running conditions. Since, in locomotive service, economy in the use of steam can always be transformed into increase of power, it may be said that the turbo-exhauster, when applied to a modern locomotive, becomes a power booster, to the extent of from 200 to 400 H. P.

The turbo-exhauster as a muffler.

One effect of the higher efficiency of the turbo-exhauster as compared with the open exhaust-jet now used is a complete elimination of all noise of exhaust. Experience has shown that a two-stage turbine wheel completely silences the exhaust of cylinders and air pumps and the roar of the blower-jet. Regarded merely as a muffler, the turbo-exhauster, unlike most mufflers, does not impede discharge, but actually brings about a reduction of pressure in the energizing steam.

The time has come when the designing engineer cannot be content with any device, however convenient or serviceable,

the action of which results in unnecessary noise. The cost of noise in dollars, and in human lives is large, and a modification in design which will permit a steam locomotive to approach the electric locomotive in quietness of operation is in itself worthy of attention.

Effect on spark discharges.

The discharge of solids from locomotive stacks has thus far refused to be suppressed. It is not that the solids cannot be separated from the gases, but that when separated, they cannot be gotten out of the front end, which, when the locomotive is operating, is always below atmospheric pressure. There have been many attempts to provide a side-door for their orderly exits, but they would never use the door; they have always insisted upon passing out through the broad avenue by which everything else finds its exit from the front-end.

In this matter the introduction of the turbo-exhauster brings about a complete change. The solids entrained by the gases are collected in an intercepting ring collector on the discharge side of the fan, where the fan pressure is maximum, and hence always above the pressure of the atmosphere. All solids thus collected are discharged by a separate pipe, preferably into the fire-box though, if the operator prefers, there is nothing to prevent their being delivered to the ash-pan or upon the road-bed.

This apparently easy disposal of the solids is due entirely to the fact that they are collected in a zone which is always at a higher pressure than that of the atmosphere. All that needs to be done to get them out of mechanism is to provide an outlet through which they may pass.

It is evident that the turbo-exhauster, by returning to the fire-box the solids which now pass out of the stack, is to be credited with such gain in the efficiency and power of the locomotive as a whole as may accrue from such action. Under present conditions of stoker firing, the effect upon output of power is complex, and I have not attempted to analyze it, but its effect upon fuel consumption cannot, I think, be questioned. Some tests of fuel in locomotive service show that wtih mine-run coal at medium power, 3 %, and at heavy power, 9 %, of the heating value of the fuel fire was discharged from the stack. There seems to be no doubt that a device which will return to the firebox the fuels thus discharged will recover these percentages of fuel.

Again the discharge of solids from the stack constitutes one of the serious objections to the presence in congested communities of the modern steam locomotive. The abatement of all such discharges, even if no use is made of their fuel value, represents a very potent advantage to be derived from the use of turbo-exhauster.

Tests of the turbo-exhauster.

Steps have been taken to advance the state of the art represented by the turbo-exhauster. The theory of the device has been re-examined, model forms of exhaust-fans and cinder traps have been made and elaborately tested, and a series of full-sized turbo-exhausters have been installed and tested on a locomotive in road service. This work of design and testing, most skillfully conducted, has disclosed :

« A complete confirmation of results predicted based on theoretical examination and analysis; that is, the device has done in service what the underlying theory said it would do.

« That its use facilitates the process of firing up a locomotive.

« That it supplies the requisite draft to make the locomotive steam satisfactorily in ordinary service.

« That the back-pressure required to maintain satisfactory draft conditions is not more than half that normally required.

« That the exhaust from the air-pump is sufficient to keep the fan turning when the throttle is closed.

« That its use supplies the same element of balance between volume of steam delivered by the boiler, and force of draft controlling volume of steam produced, as is given by the open exhaust tip.

« That in case of low steam-pressure on the road, the blower nozzle can be effectively used when the throttle is open, the blower supplementing the exhaust.

« That the noise of the exhaust from the cylinders, from the air pump, and from the blower, is eliminated.

« That objectionable cloud characteristics of the smoke discharge from the stack are diminished.

« That the discharge of solids from the stack is reduced to an amount that is negligible. »

It is but fair to add that the service tests developed two sources of difficulty, that the line of solution is in each case apparent but that the solution has not yet been worked out in service. The difficulties and the means by which it will be sought to overcome them are as follows :

The fan wheel suffered severely from the abrasive action of the solids entrained by the gases it was required to handle. The first fan put in service failed after a few hundred locomotive miles; a later fan tested withstood service for five thousand locomotive miles. The service requires a fan-wheel with can be depended upon for at least 25 000 miles. It is proposed to secure such a wheel by progress along three different lines, thus :

« 1. — By making the fan-wheel respond more nearly to smoother stream lines, and to improve the character of material from which the fan-wheel is made.

« 2. — By making certain parts of the fan-wheel heavier.

« 3. — By reducing the work upon the fan-wheel by applying to the intake tube a series of inside spiral fins, so designed as to give the approaching gases, with their burden of entrained solids, a whirl in the direction of the fan-wheel's motion, in order that the blades of the fan-wheel will not alone be required to produce rotary motion in the gases and the entrained solids. As abrasive action diminishes rapidly with reductions in velocity of impact, even slight reductions in this velocity will serve greatly to prolong the life of the fan-wheel. »

The efficiency of the turbo diminished under service conditions as a result of the accumulation of oil from the exhaust on its blades. Such accumulation was found to require attention at intervals of approximately 2 000 locomotive miles. It is obvious that the necessity for such attention would be entirely overcome if it should be found possible to introduce an oil separator in the exhaust-pipe connection, and there is a probability that such a solution can be had. In the event that it is not practicable to so separate the oil from the exhaust of the locomotive, it will be entirely practicable to inject into the turbine, at proper intervals, a solvent which can be depended upon to dissolve the encrustation.

The tests having been entered upon for a distinct purpose which did not necessarily involve the complete experimental development of the turbo-exhauster, were terminated when the purpose for which they had been undertaken had been accomplished.

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A new undertaking in apprentice training,

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Progress of the new plan of apprentice training in effect since the 1926 fall on the Baltimore & Ohio and the Missouri Pacific Railroads, in co-operation with the Railway Educational Bureau, is being watched with interest because it represents a distinct departure from methods thus far pursued on other roads.

The experiment has proceeded far enough to disclose some significant angles and to justify a description of the procedure and early experiences, for such light as they may throw on the points of chief concern to executives interested in the problem.

Briefly, the two outstanding points of difference or distinction are : *a)* the new plan operates through lessons by mail, supplemented by correspondence and periodical visits of traveling instructors, instead of through shop classes at given points; *b)* every apprentice at whatever point employed is required to pursue the work as a condition of his retention in the service; failure to do so with reasonable proficiency eliminates him after a given period, unless after due hearing his delinquencies are promptly made up or time extension is granted for proper cause. Many other differences in procedure grow out of these fundamentals.

Impressions gained from interviews with apprentices, supervisors and departmental officials on a brief visit to certain points on the two railroads, and to the headquarters of the Railway Educational Bureau [1] in Omaha, are recorded here for whatever interest they may have to railroad men who are giving particular thought to the problem of building up, not alone traffic and facilities, but men, equal to the requirements of railroading of the future. The experiment testifies at least to a growing recognition that the problem for tomorrow is not the same as that of yesterday. A skilled and competent working force is to become a more rather than less important factor in unit costs and operating ratios. Furthermore, to attract and retain such a force railroads and industries alike are already competing and will necessarily compete for the most desired type of young men with the increasing number of managements in both fields which do provide opportunity for technical and craft training whithin their own organizations.

Scope and procedure.

Before attempting to describe what has been happening in the first eight months of the new plan there should be set down a statement of its scope and procedure.

A progressive series of lessons prepared by the Bureau is sent, one at a time, to each apprentice at his home address.

[1] Hereinafter referred to as « The Bureau ».

This is preceded by an introductory explanation, to which the boy replies with a « get-acquainted » letter in his own handwriting. In this he answers such questions as the extent of his schooling, what most interested him in his school work, how long he has been an apprentice, what led him to take up his present trade and what part of it he likes best. At the same time a test sheet in simple arithmetic determines whether the apprentice is ready to start his work in mathematics with fractions or desires to « begin at the beginning ». The intent is that if his early education has been deficient, or he has been long out of school and needs to « brush up », he shall make sure of his groundwork before proceeding farther.

On a basis of two lessons a month the instruction is planned to cover a four-year period. The answers are returned to Bureau headquarters and there examined, graded, and returned to the pupil within two days as a rule, with corrections and with pencilled explanations of points which he appears not to understand. With this goes a card showing the grading accorded to his paper, if it is 75 % or above. If it is below that mark, the boy gets a personal letter from his office instructor, explaining in detail his mistakes with suggestions on how to overcome them. A copy of this letter goes to the traveling apprentice instructor.

Boys who fail to send in papers regularly or who show a grading of less than 75 %, or otherwise give evidence of unusual difficulty with their work or some particular part of it, are visited and given individual help by one of the traveling instructors, to whom the names are sent as the cases arise, and who in turn submit daily reports. There are at present three such instructors on each road, assigned to territorial districts, besides a system supervisor. Sometimes the boys are seen in rotation in the shop office at times when they can best be spared, by arrangement with the local supervision, or after working hours; occasionally at their own homes, where contact is made with the parents.

The method of general supervision of the work is slightly different on the Baltimore & Ohio from that on the Missouri Pacific. In both cases the head of the mechanical department is the ultimate directing authority and in both cases the traveling instructors are salaried employees of the railroad. On the Baltimore & Ohio the departmental headquarters handle direct certain administrative functions which, for the present at least, are cared for on the Missouri Pacific by the Bureau from its readily accessible Omaha offices, on the line of the system. On the Baltimore & Ohio the system instructor supervisor provided by the Bureau oversees and supplements the work of the traveling instructors, on behalf of both the railroad and the Bureau, while on the Missouri Pacific this service is performed by a member of the executive staff of the Bureau, working with the mechanical department of the railroad.

During the first year most of the work is the same for all classes of apprentices. Special craft instruction for each trade is scheduled to begin as soon as the fundamentals have been properly mastered. This elementary preparation includes, in one division of the work, mechanical and geometrical drawing, shop sketching and blueprint reading; in the other, general instruction, including the history of transportation, elementary mathematics, shop measurements, something about railroad shop expenses, cost of equipment, cost of delays, etc., and practical suggestions on accuracy in seeing, hearing and thinking. So far as is important or desirable the charts and other illustrative material used in sketching, drawing and blueprint reading are taken from the standard types of equipment in use on the

particular railroad. Each apprentice is supplied by the railroad with a complete drawing outfit, which remains his property if he completes the full schedule of study. He pays for his own stationery and postage.

In the second year the boy gets into projection drawing and more specialized mechanical drawing on material for his own road; his general course carries him further in mathematics and gives him something in the mechanics of solids and of fluids, with practical problems in each. From this point on his work is almost wholly related to his particular trade.

The discipline provisions.

In the first year's work the apprentice is required to send in, each month, one lesson in the drawing series and one in the arithmetic series. The plan provides automatically for elimination from the service when the apprentice is delinquent for three months, not necessarily successive, in maintaining the full schedule of two papers per month, unless reasonable explanation is shown, such as sickness or other cause beyond his control. He may be short one or both papers, for two months, without being removed, if he thereafter maintains an unbroken schedule, but unless some of this back work is made up, one more delinquency at any time without adequate cause will eliminate him. He is granted a hearing, at which if he so desires he may be represented by any other employee of his own choosing. On both roads he receives a warning after delinquency of two months. On the Baltimore & Ohio his hearing is held at the time of the warning; on the Missouri Pacific it is held when he has become delinquent for three months.

Helper apprentices of less than one year's apprenticeship, on the Baltimore & Ohio, who become three months in arrears are not removed but are set back to helper jobs, with their former seniority. Apprentices who complete their time and obtain regular journeymen's jobs before finishing their training studies are not required to complete the course but may obtain the remaining lessons if they desire, at their own expense, and it is stated that applications for such continuation are received daily. If papers are sent in which continuously fall below the required rating, after explanations by the examiners and personal help by the traveling instructors, no more lessons are sent until and unless the apprentice makes the required grade on his preceding work.

The apprentice who is dropped from the service is given one more chance. On the Missouri Pacific he may be reinstated if within ten days after his removal he brings to his supervisory officer two examinations properly filled out, provided that he promises to clear his record and live up to the schedule requirements of his technical training. On the Baltimore & Ohio there must be a similar pledge and all back work must be made up within the ten days. On neither road is he paid for the time lost between dismissal and reinstatement. If removed the second time he is not reinstated.

Much of this is something new in railroad apprentice training as we have known it thus far. There will be differences of opinion and reservations of judgment, of course, on what it will deliver in practical results as well as on the educational theory underlying it. Some of the departures from customary practice may prove more apparent than real as the plan is further rounded out, and it may be also that customary practice itself is fairly open to challenge on some of the assumptions commonly taken for granted. Certainly it will bring new attention and discussion to the opportunities still undeveloped in this promising field.

So far as concerns the maintenance of scheduled study the records in these first

few months at any rate are rather remarkable. Approximately 1 000 apprentices are employed on each system. The « active students » average on each road in excess of 900; the difference consisting chiefly of apprentices completing their time within the month and new apprentices of less than two week's service. The plan was inaugurated on the Baltimore & Ohio on 1 September 1926, and in the first seven months the percentage of apprentices who were maintaining or ahead of the required schedule of two papers each month was, respectively, 64, 66, 73, 82, 92, 87 and 86. On the Missouri Pacific the plan went into effect 15 November 1926 and in the first five months the percentages maintaining or ahead of schedule were 73, 75, 83, 82 and 87.

On the Baltimore & Ohio, in January 1927, there were 41 eliminations from service due to continued delinquency in maintaining schedules; 12 of these met the reinstatement requirements and were put back. The net removals were thus less than 4 % of the apprentice force. No surprise would have been felt, it is stated, if the eliminations had reached 20 % on this first « comb-over » of all the apprentices, the majority of whom had had no previous trade training and many of them only limited schooling. For the second period, the eliminations in February 1927 were 5, of whom 2 were reinstated; in March, 8, reinstated 2; in April, 5, reinstated 3. On the Missouri Pacific, where the plan is younger and where some delay occurred in enforcing the discipline, due to a peculiar problem in one district, there were about 25 eliminations to and including April.

A slight increase in delinquencies may develop in the next few months, for the reason that the work in mathematics is entering its most difficult phase, which promises to keep the traveling instructors more than ordinarily busy. Shop superintendents and master mechanics have been requested to give special attention to the boys during this period, for, as the letter from the Bureau points out :

« The first stage has passed. Those boys who showed no aptitude whatsoever for study work have been eliminated, but there will come a second stage where the fellow who is bright but careless, where the fellow who is superficial and does not get down to facts and fundamentals, will find himself in deep water. The only way in which such a boy can make good on advanced study work is to get down to business and make up his mind that there is no easy way to acquire knowledge; that in order to gain more than a superficial knowledge of his work, he must do more than superficial reading. »

It is further pointed out that while the apprentice instructors are endeavoring to bring home this idea to the boys, the master mechanic or shop superintendent has the greatest influence with them. « They listen to what he says. They know that he speaks with authority vested in him by his position. » And, while the boys are credited with having made a remarkable study record thus far, these officials are asked to drive home to them that there is real work ahead, that every lesson slighted or hurried over will mean that much greater difficulty later on.

Some of the pros and cons.

In other words, the same essential problems will be met here as in all systematic education. Since the boy's job depends upon his continued effort, the plan does provide more powerful motives than either the prospect of « graduation » or the fear of flunking, in ordinary school work. Will it supply also the necessary aids to proper understanding of the work required, espe-

cially in the case of boys of slow mentality or deficient in early school opportunities ? Some interesting developments are under way bearing upon this problem, to which later reference will be made. It is chiefly a question of the extent to which a real individual relationship can be established with the boy and the factor of helpful personal contact brought into play.

This factor is not likely to occupy so prominent a place in any correspondence method, even when supplemented by visiting instructors, as it does in the class-room. On the other hand, advocates of the new plan claim for it certain distinct advantages of its own. The argument is that a larger measure of individual responsability is placed upon the boy; that he must do sufficient study to complete a given schedule, rather than put in a fixed allotment of class hours per week; that the written lesson is a training in exactness and ability to express ideas; that there is less reluctance to ask questions on paper than in the presence of the brighter or better educated boys in a class room; that the time of the boys in class is sometimes consumed in discussion on the first questions raised or in help to the boys who first ask for it, most of them being at different stages in their studies and, except at large points, pursuing a variety of trade subjects in their later work; that there is such a thing as making it too easy for the boy to obtain immediate personal help whenever a difficulty is encountered; that, in fact, the modern educational tendency is towards independent effort and self-help on the part of the student.

Attention is called in this connection to the recent action of Harvard University in decreasing the time requirements in class and lecture attendance in order to permit of more opportunity for individual reading and study, a step towards the practice of English universities in this regard. No close parallel can be drawn here, of course, since the problem of mental preparation and general environment for study purposes is one thing with the college student and quite another with the average shop apprentice, but it is true that the general tendency is in evidence.

In the case of railroad apprentice training the further claim is made for the new plan that under it *all* apprentices on a given road, wherever employed, can be given the benefit of the training, while under the shop class plan the work is usually carried on only at points where enough boys are employed to justify regular class sessions and facilities. In cases where boys at outlying points are alternated at intervals with those at the larger shops, to give them a share in the class instruction, it is pointed out that the boys so exchanged necessarily lose some part of the training opportunity, apart from the question of added expense.

From the management standpoint, stress is laid on the fact that practically all the work is done by the boys on their own time, outside of working hours, except for individual appointments for help by the traveling instructor at times convenient to the supervision. It is pointed out that not alone is the direct financial economy a substantial one but that this plan avoids withdrawal of groups of boys during shop hours, thereby eliminating interference with the schedule of the mechanics they assist. This has been avoided under the shop class plan in certain instances by holding the sessions after hours, the boys being paid for all or a part of this extra time spent in class. Objection is put forward to this alternative on the ground not only of the additional cost in itself but of the twist given to the boy's view of the whole matter. The contention is that he should regard this study, not as a part of his

regular current job to be paid for, but as an opportunity, as much in his own interest as in that of the company's, particularly at a time when technical training is becoming more and more a necessity to the boy who hopes to advance.

It goes without saying that none of these contentions will be accepted offhand and without challenge. They are set down as the grounds upon which advocates of the new plan justify it in theory and expect it to justify itself in practice. As with all innovations its advantages are urged with energy and enthusiasm, but it is only fair to say that the plan is not put forward as the final and faultless word on the apprentice problem in railroading.

The question of personal contact.

At just what points or in what ways do the elements of personal contact and group interest enter into the working program as developed thus far ? From some viewpoints this is an aspect of apprentice training hardly second to that of the actual instruction given.

A certain degree of personal flavor can be injected, of course, even into correspondence with apprentices regarding their work. It need not be purely a matter of formal printed lessons, handled mechanically by routine examiners of whom the students know nothing. At Omaha the lesson papers arriving each day are distributed in such a way that a given examiner, for the most part, sees the work from the same group of boys. Those with whom I talked say that they can and do become familiar with the characteristic aptitudes, difficulties and mental slants of many of the apprentices and establish a direct relation with them by name, in connection with the explanations of errors and the asking and answering of questions. Many of the file letters written by examiners to individual boys who have not made a passing grade do exhibit the personal note of encouragement and advice and go into detail on the particular sources of trouble. There are indications to be seen in current work going through as well as in reports from traveling instructors that some at least of the boys show a considerable appreciation of the help given in this way.

Supplementing this, exceptionally good work on the part of an apprentice is called to the attention of his supervising officer, sometimes to that of a higher executive as well. In one interesting instance on the Baltimore & Ohio an electrician apprentice who had sent in some notably excellent sketches was given a trip to Baltimore, shown the electrical equipment and applications at the terminal, and personally encouraged in his work by the superintendent of motive power.

Individuality crops out to some extent, as might be expected, in the « get-acquainted » letters received in reply to the introductory letter to each boy, already referred to. « Do not hesitate to write us a long letter if you wish, » is the invitation given : « The more we know about you the easier it will be for us to help you. »

Cullings from the mail.

I had the opportunity to inspect the entire mail, of several hundred letters, on two mornings in Omaha, including lesson papers, get-acquainted letters from new boys, questions, irregularities, and reports from traveling instructors. An interesting compilation might be put together of extracts from these human documents. They are by no means remarkable in themselves, but do afford impressions of the personality and mental preparedness of boys about to embark on a given educational program. Here are a few sentences, taken at random

from the mail of these two mornings, from both roads :

« I was not overloaded with education, » wrote a helper blacksmith apprentice, who had quit school in the 7th grade to go to work. « To tell the truth I never was very fond of arithmetic or English in school. I did like physiology, history, spelling and geography. And I'm willing to learn anything else I can. I'm sending my first lessons with this letter, so if you can read this letter maybe you can read my lesson answers. And if I find a problem that I cannot get or figure out I'm going to ask help from you instead of letting someone else get it for me. »

« I am a machinist helper apprentice, have been in the service a little over two years, » said a young man in one of the large shops. « I like the work fine and like machine work better than the work on the erecting side. I have been out of school about eleven years. » Another boy wrote : « The work in school that interested me most was along the manual training and machine shop line. I graduated from school in 1924. This year making three I have been out of school. Those three years make me see what I was doing. I was just drifting around, working every place but mostly not working at all. Those three years convinced me more than anything else that I needed a trade... My ambition is not to stay at the bottom of the machinist ladder, but to go as high as I possibly can. » This from a blacksmith apprentice : « I want to keep on the addition, subtraction, multiplication and division, for I feel that I am not qualified to study fractions. Yet when you think I can start fractions you may send them on to me. I just went to the sixth grade in the public school. You know that I have not got much education. I am hoping that I can go through with your schooling O. K. »

To the question in one of the introductory lessons why an apprentice should set a goal of accomplishment for himself a helper painter apprentice answers : « I think about as good a reason as any is that he will go about his work with a lighter heart, find more pleasure, and do better work. And another thing is that a fellow cannot succeed or accomplish anything if be hasn't anything to work to. If a man does not care for his work he will be sure to fail. »

The characteristics of a good leader, as observed in men of their own craft, says a boilermaker apprentice, are : « Interest in his work, always trying to do more and learn more than is required of him, to study and observe and listen to the things that are did and told to him by men higher than himself. Honesty and respect to all fellow men. »

A car builder apprentice thinks that the advantage in showing interest in work and courtesy to associates is that « the other fellowmen will take an interest in you. If a man tells you anything, one should listen closely to what is said and if you do not wait until he is finished you can hardly expect a courteous reply from him the second time ». The same boy believes that the advantage of a technical training plus practical experience, over experience alone, is that the apprentice « will learn more faster how to do the work better and more easier and yet he will be promoted more quickly. »

Whatever else such communications may indicate, no one is likely to suggest « internal evidence » of copying from a lesson book ! It should be noted that in this first year the examiners are not making corrections in spelling and grammatical forms, the grading having to do wholly with the boy's understandings of the lesson problems.

A machinist apprentice, who connects his lessons with his shop experience and associates, illustrates thus his idea of

sketching and sketch-reading: « At some time an engine might break down on the road and some complicated part broken some one would have to make a sketch of this part and if not properly sketched it would cause a lot of delay waiting for it... Say I was running a lathe and Carl brought me a sketch of an appliance he wanted to have made and try out. I would have to be able to make it from the sketch. »

In the mail was a letter from a sheet metal worker apprentice, one of four who had recently made a visit to what they call « the school », in Omaha, and who apparently had written for help on some of his work. The explanation, he says, « was very satisfactory in every way and I hope I will not have to bother you any more... I feel free in writing you about anything concerned, realizing that it is quite a task that you have on hand to handle all the school transactions. »

Whatever significance such pickings from a typical mail may have, unimportant in themselves, lies in the extent to which, be it much or little, they disclose elements of personality to the examiners who must work back and forth through this means chiefly, and to the instructors and supervisors who are expected to make direct contacts with the boys on the job.

The instruction staff.

The personality, experience and special aptitude of the traveling instructor will necessarily have much to do with the problem of getting at the individual boy, of measuring his capacities, affording him sufficient but not too much help with his difficulties and the kind of friendly encouragement he needs. All the instructors on the two roads are men of practical shop experience, two of them in mechanical engineering, the others as mechanics in various crafts and with further service either as draftsmen, inspectors or foremen. All have served previously as teachers of apprentice classes, either on other roads or under former training systems on the road of present employment.

One was for several years director of vocational work in the public schools of a large city and later of the manual arts department in a high school. Both of the system instructor supervisors, five of the traveling instructors, and one shop instructor on schedule work who also assists boys in their studies as required, have themselves served a mechanical apprenticeship. Both the system supervisors have served as foremen and one of them as president of the system machinists' organization.

I made the acquaintance of four of these gentlemen and visited shop points with two of them; a fifth I had previously known. All are unlike in personal characteristics, but each gives the impression of a practical and human rather than a schoolmaster view of his work. Of their interest in it there can be no doubt. The examiners, at Omaha, are men of more varied industrial experience in which is represented engineering, accounting, efficiency work, drafting and design, and various supervisory functions. Six of the nine have seen railroad service; several have pursued night school or correspondence courses in technical subjects, as a part of their educational experience.

Talks with apprentices.

How much of « human interest » it is possible to inject into a plan of this type is a question not to be fully answered as yet. Impressions of only limited value can be gained from the comments of the handful of boys it is possible to see on a brief investigation, but these impressions have a certain significance nevertheless, as far as they go. I was able to interview, on the two roads, 18 apprentices, picked at random while

going through certain shops, without advance notice. Except in one case, no supervisor or official was present during these talks of from ten minutes to half an hour each. All the boys had gone through most or all of the common school grades, some had had high school experience, two or three had pursued or were still pursuing evening class work in schools for technical or trade training.

The direct question was put, whether they believed they could get as much out of their studies under this method as they would from regular class instruction. Three believed they would do better in class; these were boys who had been out of school for some years and had gone to work before high school age. Two or three were non-committal. The others expressed preference for the present method, and of these the majority gave as a principal reason that it put a boy upon his own responsibility to « dig it out ». Other reasons volunteered were that a boy could ask questions in his paper or of the instructor on his calls but would not speak up in class. On the question whether the corrections and explanations noted on the returned lessons were clear and sufficient, il was apparent that much depends on the nature of the problem. The answer was affirmative from perhaps two-thirds of the boys; the others, on the more difficult work at least, found additional help from the instructor necessary. At one point at least, possibly at others, a group of boys have gone still farther and arranged temporarily for outside help in mathematics by a local school teacher, one or two evenings a week.

Other help available.

At the large Mount Clare shops, Baltimore, where between 250 and 300 apprentices are employed, the district instructor is within reach during rather more than two-thirds of the month. Here, as at certain other shops on both roads, the local shop instructor whose duty it is to assign apprentices to their work schedules and give floor instruction is available at practically any time to assist boys who come to him with questions on their studies. At Mount Clare this official was himself an apprentice instructor under a former plan. These shop instructors are a part of the regular shop organization and not of the new training plan as such, but they have the important job ahead of co-ordinating so far as practicable the floor instruction on machines and operations with the studies the boys are pursuing.

At several points on both roads the boys are at liberty to use certain rooms at the shops for study after working hours or for meeting instructors. At one important point on the Missouri Pacific, arrangements were under way to assign certain supervisors of special qualification, in rotation, to spend an hour perhaps twice a week after the 3.30 p. m. closing in attendance at the designated room to help any boys who might come there for questions or study.

At North Little Rock shop the apprentices have formed a club, holding weekly meetings, at which any question in the training course may be put and discussed; if it is not answered satisfactorily note is made to bring it up at the next meeting attended by the traveling instructor. The boys here have appointed a committee to investigate delinquents among their own number and impress upon them the importance of maintaining the schedule, as well as to give assistance when necessary. They have invited the local supervisors to attend, and thus far have had a talk from some supervisor at each meeting. Some indications of team rivalry crop out in a development of this sort. It was in evidence at another point where the 18 apprentices employed had a

100 % record of papers turned in on or ahead of schedule. One of the boys here, with whom I talked, remarked that they « didn't propose to let the bunch at ——— get ahead of them ».

The boys at North Little Rock have included social features, assessing themselves 25 cents per member as monthly dues for the purpose. At Osawatomie, Kansas, about half the members of the railroad « Boosters » baseball club are apprentices. At Mount Clare, Baltimore, many of the apprentices are already members of the local relief association which has its social activities, and some are members of the shop band. But the club idea for apprentices only is apparently making headway, especially at smaller points where counter attractions are less numerous.

Reaction on the supervision.

One of the hoped-for results of the plan in the minds of its projectors was and is to turn the boys towards their own supervisors for help in their studies as well as their work, at least in the intervals between visits of the traveling instructors. Inquiry of the apprentices interviewed indicates that actual help from this direction, for some time to come, will be limited to occasional cases of individual aptitude and interest, of which it is true there are some encouraging instances. One of the reports from a traveling instructor, for illustration, quotes an apprentice at a Colorado point as saying that « he had never had a foreman take a personal interest in him », but that since he had embarked on his present studies « his foreman had visited him at his home several times to go over questions that bothered him in his lessons. » The foreman in question, being interviewed in turn, expressed the idea that the work « made a foreman get acquainted with the boys, and that incidentally he was getting as much help out of helping the boys as he was giving. »

But as a general rule, thus far, it appears as might be expected that the average foreman is « too busy » with the production drive during shop hours, and is not likely to be available for help after hours, except by special arrangement. Furthermore, a considerable proportion of the foremen have themselves had no opportunity for technical training beyond what could be picked up in their own shop experience, and here an interesting by-product of the present plan is already making itself felt, in spots. There are instances on both roads of mechanics and supervisors who have taken up for themselves the studies required of the boys.

One machinist, for instance, who began his own studies in the fourth month of the new plan writes that he was led to do this « by the comments of apprentices at the shop who are being schooled ». In other instances the inciting motive rather obviously has been the difficulty of answering questions raised by the boys. What is in evidence here, although too meagre for safe predictions, accords with the outcome of an experiment with which I was closely familiar on another road. A class for foremen and one in more elementary work for mechanics had been started at the same time, but it was promptly found necessary to cover the same ground with both.

It will be well worth while to watch the extent and results of this pressure from a large body of « mechanics-to-be » upon men already higher up in the ranks. What reinforcement may it give to the argument for systematic foreman training, as well as for greater attention by managements to the opportunities for technical study by adult mechanics ? Foreman training, indeed, covers a range of problems peculiar to itself, in advanced shop practice and the success-

ful handling of men, but until all our mechanical forces are built up from the ranks of those who have had the groundwork of technical training such as is now available to apprentices on a number of roads there will be a serious break in the continuity of our provision for fully efficient supervision.

The attitude of supervisory forces on the job, so far as opportunity was found to discuss the subject, was strongly favorable to the working of the plan thus far. At one point I was taken through the shop by a foreman who had been particularly skeptical of the early arguments advanced for the experiment, but who gave me reasons of his own for expecting of it a material improvement in quality, both of the apprentice forces and of their shop work. It is safe to assume nevertheless that it will be more or less unwelcome to the foreman of the type who dislikes to be troubled with questions from boys or who may imagine his own job menaced by too much improvement in capacity and knowledge farther down the line.

In the approval voiced by several of the supervisors interviewed, a rather interesting and human aspect was the fact, as they put it, that the dropping of delinquents from the service through a method uniform for all automatically weeds out most of the boys who have not the « makings » of good mechanics, those they would like to dispense with anyway for the good of the service, and in so doing relieves them materially from suspicion of favoritism or prejudice or from the « influence » of relatives and friends.

The monthly test, and examination of applicants.

It is freely acknowledged by officials on both roads that the plan is likely to require adaptation to conditions, as experience may suggest; in fact, some stress is laid upon its « elasticity ». Some changes, and particularly additions to the early practice, have already been made. Development of the club feature, now getting under way, is one such. A monthly test or quiz and general discussion for all the boys at a given point (taken in sections at the larger points) is being given by the traveling instructors. The object in part is to check up on those who may be copying the work of others, and in part to establish personal contact not alone with the boys needing special help, who are seen on the semi-monthly rounds, but with the larger number who are making the grade, so far as the records show, but are no less entitled to attention and encouragement.

The « quiz » in these instances is oral, intended to last from on to two hours, but in the latest instance related to me on the Missouri Pacific the boys had kept the instructor until nearly midnight with discussion on the test questions he had used. These questions he prepares in advance with special reference to current work of the apprentices at the given point. On the Baltimore & Ohio the oral test has been used for the same purpose, when and as the instructor believed it desirable for certain boys, and is now being made a regular monthly routine.

How to make sure of honest individual effort, without cribbing, is a problem met in some measure under any and every educational system from the first year in the common schools to the last year in college. Where mail lessons arrive at about the same time, copying is comparatively easy to detect in the case of sketching and drawing and of questions requiring answers in the boy's own language; it is more difficult to trace in the case of mathematical problems where one boy can borrow the corrected lessons of another farther along in his work. How much of this is actually going on in the present instance it is

difficult to estimate. At one and the same point some boys have told me that a large amount of cribbing is done, while others have been equally positive that it is limited to those who « wont't work anyway ».

At two points there were boys who remarked that the oral tests applied by the instructors had uncovered some of this evasion and that the effect had not been lost upon others. Supplementing these tests a periodic written examination in mathematics went into effect in June on both roads and the corrected papers are returned, not to the apprentice, but to the chief mechanical officer. It is a test at long range, although not different in that respect from such a system as the New York State Department of Education has employed for many years in the periodical written examinations in high schools, conducted by the University from Albany.

The borrowing of corrected papers was made easier at first probably by the privilege afforded to those who get ahead of schedule to suspend work until the routine is overtaken. The present view is adverse to this practice, not so much however because of the opportunities it affords to cribbers as of the unsatisfactory results to the boy himself of a spasmodic study program. The rule is under consideration that an apprentice must come up to a certain standard on his grades before being allowed to go ahead of schedule, and maintain two lessons a month in any event.

It is true, of course, that new boys entering the service can have access to the corrected papers of those who may have kept them and are disposed to lend, but the entrance examination now given on the Baltimore & Ohio, and that just going into effect on the Missouri Pacific, are of a character to admit only boys already well qualified to go on with the apprenticeship studies.

The examinations specifically ask if these requirements are understood, including the possibility of elimination from the service if the schedules are not maintained. They embody a promise to make honest effort to assimilate the training and keep up-to-date. They contain examples in arithmetic, some of them in railroad terms, recite the applicant's personal and family history, including his school experience, name the trade he desires and his previous service, if any. A letter must be filed, from the school attended, certifying to the grades completed.

Attitude of the boys.

It would be natural to expect that a large proportion of boys already in service would not voluntarily embark upon such a course of study. The ranks of the voluntary self-educators, even of collegiate grade, are seldom overcrowded anywhere, for that matter. The question was put to all the apprentices seen, with varying results. Most of the boys at the smaller points believed that the majority would now elect to go on with the work, whether compulsory or not. At large city points it was the prevailing idea that only an ambitious minority would undertake it, if left to their own choice. Of the boys actually interviewed, however, perhaps two-thirds answered without hesitation that if they had the choice of several jobs, only one of which provided technical training, they would take that job, even with the dismissal rule for failure to maintain schedule.

It would be quite too optimistic to infer that this is the view of most of the apprentices; it would be surprising if one-third of a force employed without anticipation of a study program were to make such a reply. Very probably many boys who have left school to go to work have done so in part to escape further study. The significant thing is,

nevertheless, that on both roads there is today a long waiting list of boys who have applied for apprenticeship jobs, knowing what is required, and that a large majority of the recent applicants are boys with high school experience, many of them graduates. If this situation is maintained it gives us an interesting forecast of what the selective influence of training opportunities promises to be, in drawing a distinctly higher type of young men into the mechanical departments of the railroads.

Conversation with the boys led into a broader question. To what extent does the average apprentice realize that with the growth of technical education generally the time is approaching both in industries and railroads when substantially all skilled employees will be men who have had systematic training, a large proportion within the industry itself, and that boys not so equipped will more and more find themselves « out of it », obliged to take laborers' jobs or find other unskilled occupations ?

It was the majority opinion that few of the boys ever gave the matter serious thought. Presumably, under any plan of apprentice training, there is a larger percentage of forethought and interest after the work has been in progress long enough for at least one cycle of apprentices to pass through the four-year period, so that all apprentices in service are boys who knew of the study obligation in advance. When this plan went into effect the importance of training to the boy as well as to the company was pointed out in talks and circulars, and on the Baltimore & Ohio particularly it has had attention in the company's magazine. But, it was believed, not many boys think much beyond the day or the week. This rather pessimistic view, again, was more in evidence in the cities than at the smaller shops. But it suggests the desirability of more thorough « publicity » with the boys themselves, for making clear the conditions ahead and the opportunity afforded.

The compulsory requirement.

The compulsory feature will of course raise doubts in many minds. Is it fair to remove boys from service who do not care to study, or who may lack the mental capacity ? Is it just to require them to study on their own time ? Is there any practical value in education forced upon boys whose own ambitions do not bring them to it voluntarily ? The reaction of organized labor to these questions also comes in for question.

In reply the contention is made that a management is under no obligation to retain boys who show no willingness to qualify for more efficient service; that ample assistance is offered to backward boys; that an educational requirement by a corporation is not different in principle from that which the community imposes in the common schools, irrespective of the ambitions or mental capacities of the students. It is rather interesting in this connection that, as a matter of fact, in several of the colonies in early days employers were required by law to train up to a useful trade any apprentices they might indenture, and were themselves subject to penalties for neglect of this obligation.

So far as concerns the attitude of labor, on the two roads in question the new training plan was put into effect with the endorsement and cooperation of the organizations with which, respectively, agreements are held. The rules governing apprentices, in the agreements, have been amended by mutual consent to provide for the new training requirements, including the elimination feature under stated conditions. The probable attitude of organizations on other roads remains to be seen, if and as the question arises.

Is it a « 50-50 » proposition?

It would be interesting to know how the boys themselves regard the question of fairness in having to study on their own time. So far as I could gather from conversation with the 18 apprentices referred to, there are two elements among those who object to the new requirements; one, the boys who do not want to study at all; the other, and presumably larger, those who would be quite willing to attend a class on company time, without definite requirement to maintain a specified schedule in order to remain in the service. One boy suggested that some of the fellows would rather sit in a class and be paid for it than work on their jobs!

General conclusions are not warranted upon the opinions and ideas of so few witnesses, though picked at random, except perhaps as reinforced by other experience and knowledge of human nature. Much depends of course upon whether the boys look upon the technical training as an opportunity, for themselves, or simply as something wholly in the interest of the company. Those to whom the question was put directly, whether it seemed a fair 50-50 proposition that the company put up the expense of the lessons and instruction, against the boy's time and effort, both deriving a benefit in the long run, replied in every case in the affirmative. This might be called a « leading question », it is true, with only one answer reasonably possible, but it is after all the point to which the issue comes down. Advocates of the experiment look to this point of view to win its way, especially as those who may be unwilling students complete their time or drop out and are replaced by new boys. They describe it as a step away from paternalism, a method based rather upon the cooperative idea. Beyond doubt, it furnishes plenty of material for discussion and gains in interest accordingly.

A contribution to renewed interest.

The arguments pro and con are by no means closed. The attempt on the Baltimore & Ohio and the Missouri Pacific strikes in a new direction in method, although not in ultimate purpose. It is fortunate in having unqualified official support on both roads, and in each case a mechanical officer in direct supervision whose practical experience and initiative are rather peculiarly fitted to the human requirements of such an undertaking. The importance of these two prime essentials of success in any personnel undertaking can hardly be overestimated.

No one type of apprentice training is likely to monopolize all the desirable features, but there is something to be gained in having experiment under way and unlike methods on trial. The plan here described will quite probably undergo further changes in scope and detail. It is at any rate a contribution to renewed interest in the problem of enlisting and training in railroad service a high type of young man, with an eye upon not only today's job but upon what lies beyond. As such it is entitled to a fair statement of the claims made for it and of its working thus far.

[656 .256.3 (.73)]

The automatic block system in the United States. [1]

Figs. 1 to 52, pp. 38 to 81.

(*Revue générale des Chemins de fer.*)

Introduction.

Statistical information.

The first tests of the automatic block system in the United States were made in New England in 1881; it was only in 1879, the date the track circuit was introduced, that a substantial number of automatic signals began to be provided. The first signals called « Banjo » were operated by means of electro-magnets.

In 1882, the first semaphore, operated electro-pneumatically, was erected at Est-St.-Louis. The first signal worked by electric motor was made in 1900. Up to that date, all such installations were worked with continuous current. In 1903 the first track circuits using alternating current were installed in California, and made it possible to use automatic signals on electrified railways.

The first tests with « daylight signals », which give light signals by day as by night, were made in 1913.

Since 1913, the extension of the automatic block has been considerable. Continuous technical progress has been made in perfecting the apparatus and in its erection.

The curve of figure 1 shews the growth of the manually operated block and of the automatic block between the 1 January 1900 and the 1 January 1926. In 1900 the length of line fitted with the manually operated block was 38 000 km. (23 600 miles), whilst the length with automatic block was very small (about 3 200 km. = 1 900 miles. From 1900 to 1906, a marked growth of the manually operated block (about 32 000 km. = 19 900 miles fitted) will be noted, whilst the growth of the automatic block did not exceed 8 000 km. (4 970 miles).

Subsequently to 1906 the use of the automatic block extended rapidly, 37 000 km. (22 990 miles) being equipped between 1906 and 1914, the extension of the manually operated block amounting to barely 32 000 km. (19 900 miles) during the same period.

Since 1914, the number of lines equipped with the manually operated block has tended to diminish : on the other hand, the use of the automatic block continues to increase, 27 000 km. (16 780 miles) being fitted between 1914 and 1926).

It will be noted, furthermore, that the

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(1) The present article is a *résumé* of a report made by Messrs. Japiot, Tuja, Dargeou, Santini and Bocquet, Engineers of the Paris, Lyons and Mediterranean Railway Company, who had been sent to investigate the various antomatic block installations in the United States. It will only deal with the use of the automatic block on lines with a definite direction of running. It should be recalled that trains run on the right-hand road in the United States : the signals are therefore placed as a rule on the right-hand side of the driver to whom they apply.

Reference can be usefully made to the article by Mr. Balling, published in the *Revue générale des Chemins de fer*, of November 1920.

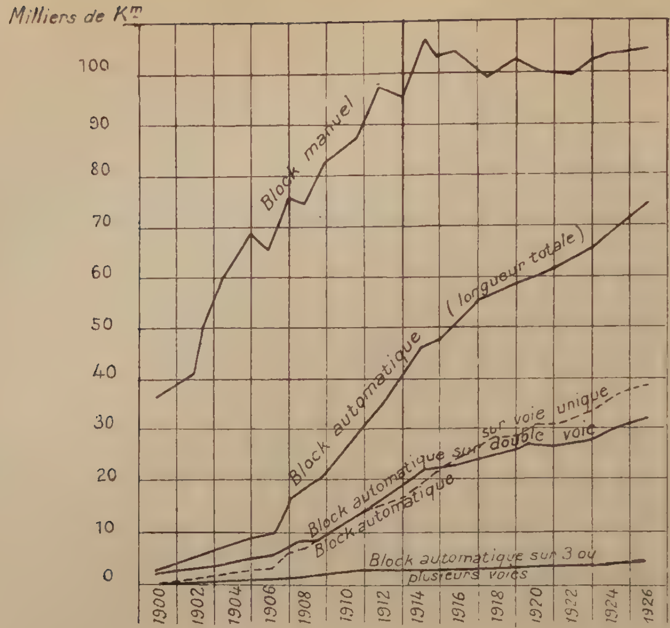


Fig. 1.

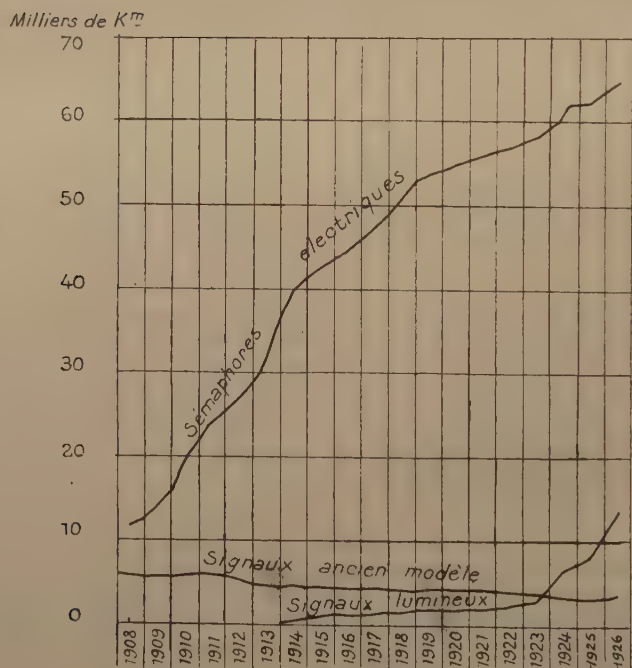


Fig. 2.

Explanation of French terms in figures 1 and 2 : Bloc automatique (longueur totale) = Automatic block (total length). — ... sur double voie = ... on double line. — ... sur voie unique = ... on single line. — ... sur 3 ou plusieurs voies = ... on 3 or more lines. — Block manuel = Manual block. — Milliers de Km. = Thousands of kilometres. — Signaux ancien modèle = Old pattern signals. — Signaux lumineux = Daylight signals.

automatic block was installed on single lines in but few cases before 1906; since that date, however, the number of installations has increased as on the multiple track lines and the increase has been more marked the last few years. This must be taken as a consequence of the fact that most multiple track lines with heavy traffic have now been fitted. As a matter of information, 65 % of the work done in 1925 was on single lines.

The diagram of figure 2 shews for the different kinds of signal, the growth of the automatic block. The steady and rapid increase in the number of electric semaphores and the growth, since 1914, of daylight signalling will be noticed. In 1925, 1 000 km. (620 miles) of line were fitted with electric semaphores and 1 760 km. (1 090 miles) with daylight signals. These figures had become 2 650 and 5 980 km. (1 650 and 3 715 miles) in 1926.

The proportion of lines with daylight signals was 8.3 % at the 1 January 1925, and reached 10.4 % at the 1 January 1926, and 16.5 % at the 1 January 1927.

The following table gives the distribution of the different kinds of signals at the 1 January 1927 :

		Length of lines.		Length of track.	
		Kilometres.	Miles.	Kilometres.	Miles.
Different types of automatic block signals.	Electric semaphores	65 000	40 390	99 500	61 830
	Daylight signals :				
	Coloured . . . 11 900 km. (7 395 miles)				
	Position . . . . 1 700 km. (1 055 miles)				
	Total daylight signals	13 600	8 450	20 600	12 800
	Old signals	3 700	2 300	8 400	5 220
	Sum total of the automatic block	82 300	51 140	128 500	79 850

The number of automatic block sections amounted at the 1 January 1926 to 73 984, which made the average length of the section 1 590 m. (1 739 yards).

SIGNALLING AND SIGNALLING REGULATIONS ON LINES FITTED WITH THE AUTOMATIC BLOCK.

Many types of signals are to be found in the United States of America : a marked tendency is noticed towards the adoption of standard signalling practice to a consideration of which the present article will be limited.

I. — Principles of American signalling pratice.

The modern automatic signalling of the American railways is characterised by the following features :

1. The spacing and protection of trains are assured by three indication signals : line clear, caution, stop;

2. The signalling of junctions gives the driver warning of the speed to be observed at the junction and not as to the direction given him. The passing speed is shewn without using a special signal by means of several spacing signals and protecting signals carried on a single signal post.

Spacing of trains. — The spacing of trains is assured by a number of signals giving three indications which inform the drivers as to the state of occupation of the line. The line clear signal shews that the two following sections are not occupied : the caution signal shews that the first section is clear but that the second section is occupied : finally, the stop signal shews that the section is occupied.

When finding a signal at danger, the

drivers limit their action to marking the stop. They then proceed to pass the signal which is a *permissive* signal, and enter the section at caution.

A permissive signal at danger can in some cases be passed without stopping. The signal in such instances has some additional sign (such as an additional arm or a plate lighted by night) which makes it into a « *grade signal* ». This exceptional arrangement is only used on heavy gradients where it is very difficult to start, and only applies to goods trains of heavy weight, all other trains having to obey the stop as at an ordinary signal.

Protection of stations. — Train movements in small stations are covered, as we shall see later, by the three indication permissive signals placed immediately before arriving at them.

As soon as the station is of some size it should be covered by a signal which must not be passed, konwn as an *absolute* signal, in contradiction to the permissive signals. This signal, worked by a lever and interlocked, is none the less a block signal depending on the working of the track circuits. As such it assures the spacing of the trains at the same time as covering train movements in the station. An absolute signal differs from a permissive signal in constructional features (shape of arm, arrangement of lamps). The absolute signal, like the permissive signal, is of course worked in conjunction with the preceding signal which conveys the warning (fig. 3).

When designed in this way, an absolute signal depends :

1. Upon the track circuits;
2. Upon the interlocking in the station.

It may happen that the track circuit prevents the signal being put to line clear, although the interlocking does not oppose in any way the reversal of the signal lever, and it may be necessary in these circumstances that a train should be able to pass the stop signal. This situation arises in particular when the signal is affected by some electrical defect or when, the track circuit being occupied, it is necessary to go into the section to attach or detach vehicles from the rear of a train.

The absolute signal should then, generally speaking, be completed by some indication shewing it can be made permissive. Such is the object of the auxiliary passing signal known as the « *call on* » signal.

The « call on » signal is a supplementary signal placed below the principal signal. It can give three indications which have the following meanings :

First indication. — Obey the indication of the main signal which must not be passed at danger.

Second indication. — Slow speed and caution. The principal signal may be passed at danger, but you must run at slow speed and be prepared to meet some obstruction (case in which the track circuit is occupied).

Third indication. — Slow speed [1]. You can pass the principal signal at danger but you must run at slow speed.

This last indication of the « call on » signal is used then even if the track circuit is unoccupied, and there is nothing to prevent the main signal being put to line clear. It ensures the speed of the train being reduced (to about 20 km. [12 miles] an hour) so that it can be turned into a holding siding or avoiding siding through facing points.

It is to be observed that the « call on » signal authorises the passing of a signal without making it obligatory to stop. An absolute signal, made passable by a « call on » signal is therefore from this point of view less definite than an ordinary permissive signal.

Figure 4 shews, as an example, the principal instances of the use of « call on » signals.

(1) This third indication is not used by all the companies.

Signalling at junctions. — The American railways have abandoned route indicators at junctions. In their opinion they were not indispensable : they required, furthermore, when there were many branches, complicated signals; their indications were often seen too late, and did not prevent a carelessly handled train running on to the junction points.

The indication of the speed to be observed is, on the contrary, extremely valuable from a safety point of view : furthermore, it is given just as well some distance away as at the place at which it is to be observed. As was said at the beginning of the article, no special signal is provided to give this indication, which is obtained in the following ways by the grouping of several signals giving three indications.

The junction (fig. 5) is immediately preceded by a signal post carrying three superimposed signals (*branch signal post*) :

1. An absolute signal S_1 with three indications relative to the movement of trains at high speed (main line);

2. An absolute signal S_2 with three indications relative to the movement of trains at reduced speed (branch line);

3. A call on signal S_3 (1).

The post carrying the distance signal is the preceding *permissive* block signal which is repeated as two signals S'_1, and S'_2, carried one above the other on the same post (*junction approach signal post*).

Leaving aside the working of the passing signal S_3, which has been described already, we will now consider the positions of the signals S'_1, S'_2, S_1, S_2, under the different conditions. The following table summarises the indications given :

INDICATION GIVEN.		INDICATIONS OF THE SIGNALS : S'_1 and S'_2 on the outer branch signal post.		INDICATIONS OF THE SIGNALS : S_1 and S_2 on the junction signal post.	
		S'_1	S'_2	S_1	S_2
Main line.	1. Line clear. Full speed (*Main line*)	Line clear.	Stop.	Line clear.	Stop.
	2. Full Speed. The signal following the junction on the *main line* is at danger . .	Do.	Do.	Caution.	Do.
Branch line.	3. Line clear. Reduced speed (*branch line*).	Caution.	Line clear	Stop.	Line clear.
	4. Reduced speed (*branch line*). The signal following the junction on the branch is at danger . . .	Do.	Do.	Do.	Caution.
Stop.	5. The junction must not be passed (unless permitted by the call on signal) . .	Caution.	Stop.	Stop.	Stop.

(1) In the case of junctions with more than two branches, the signal post always carries only two absolute signals, one dealing with the main line, the other with the branches.

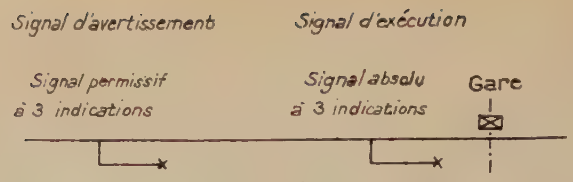
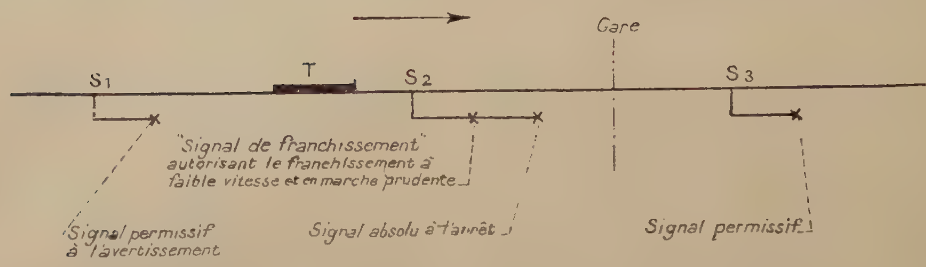
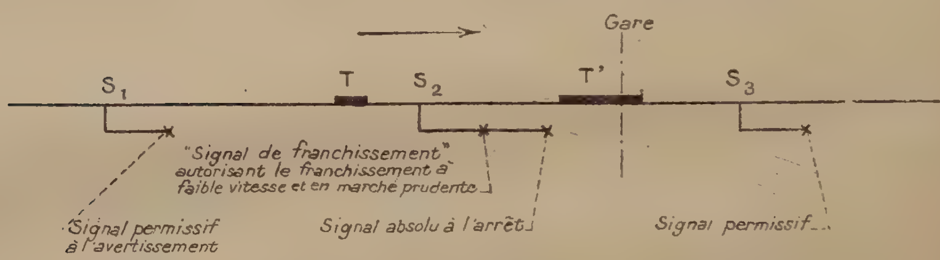


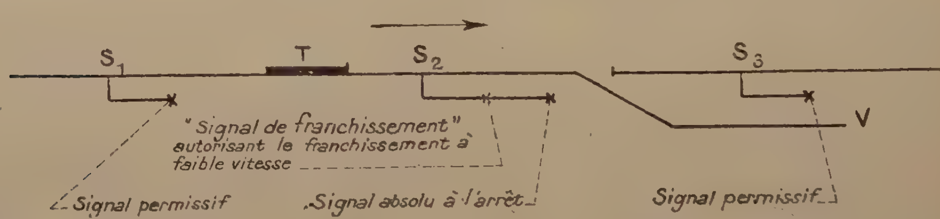
Fig. 3



A _ Un dérangement électrique existe entre S_2 et S_3



B _ On désire faire un retrait ou une adjonction en queue du train T'



C _ Le train T va entrer sur la voie de service V

Fig 4. — Examples of the use of the « call on » signal.

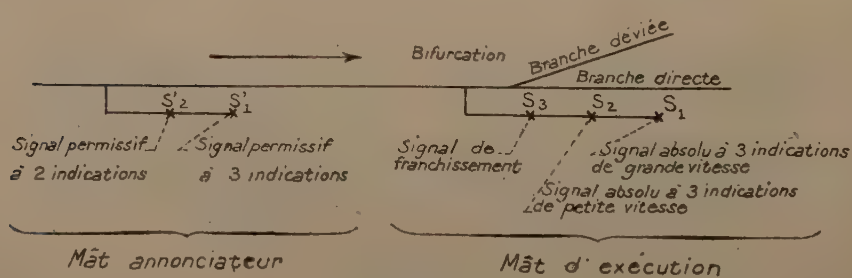


Fig. 5.

For explanations of French terms, see opposite page.

Explanation of French terms in figures 3, 4 and 5 :

Bifurcation = Junction. — Branche déviée = Branch line. — Branche directe = Main line. — Gare = Station. — *C*. Le train T va entrer sur la voie de service V = The train T is going on to the siding V. — Mât annonciateur = Distant signal post. — Mât d'exécution = Home signal post. — *B*. On désire faire un retrait ou une adjonction en queue du train T' = Stock is to be detached from or attached to the rear of the train T'. — Signal absolu à l'arrêt = Absolute stop signal. — Signal absolu à 3 indications = Three indication absolute signal. — Signal absolu à 3 indications de grande vitesse = Three indication absolute signal for high speed. — Signal absolu à 3 indications de petite vitesse = Three indication absolute signal for low speed. — Signal d'avertissement = Caution signal. — Signal de franchissement = Call on signal. — Signal de franchissement autorisant, etc. = Call on signal permitting the signal to be passed at slow speed and at caution. — Signal d'exécution = Home signal. — Signal permissif à l'avertissement = Permissive caution signal. — Signal permissif à 2 indications = Two indication permissive signal. — Signal permissif à 3 indications = Three indication permissive signal. — *A*. Un dérangement électrique existe entre S_2 et S_3 = An electrical defect exists between S_2 and S_3.

The driver in this way is given at the junction itself a signal S_1 governing full speed and a signal S_2 governing reduced speed. One of these signals is always at danger and the driver obeys the other, *his speed being determined by the kind of signal which authorises the passage : the upper signal S_1, full speed; the lower signal S_2, reduced speed.* The distant signals S'_1 and S'_2 give the position of the home signals S_1 and S_2 (1).

Taking the call on signal into account, the signals S_1, S_2, and S_3, enable three different speeds to be prescribed :

1. Full speed (passage on the main line) which may reach 100 to 120 km. (62 to 75 miles) an hour;

2. Reduced speed (passage on to the branch) at about 40 km. (25 miles an hour;

3. A low speed (line occupied or shunt) about 20 km. (12 1/2 miles) an hour.

For this reason, the system of signalling just described is sometimes known as *three speed signalling.*

To sum up, the American automatic signalling makes use of the following signals :

Permissive signals :

— Permissive spacing signals giving three indications;

— Outer junction signal post (two permissive signals superimposed);

Absolute signals :

— Absolute stop signal post (a three indication absolute stop signal and one call on signal);

— Junction signal post (two three indication absolute stop signals and one call on signal).

II — Types of American signals.

The American Railways use two types of signal :

Semaphore signals;
Daylight signals.

These signals are used in accordance with the principles considered in the preceding paragraph, and as a rule give three indications. A study of these signals may be summed up by a consideration of the way these three indications are given, whether by the position of a semaphore arm or by the colour or position of light signals.

Semaphore signalling. — The arms of the three position semaphore signals

(1) It will be noted, however, that S'_2 gives two indications only : line clear and stop. When the signal S_2 is at danger, S'_2 is not at caution, but at danger. The Americans consider that with this arrangement there can be no mistake in interpreting the signals.

work in the upper quadrant and give the three following indications :

1. Vertically upwards (a green light) : line clear;
2. 45° upwards (orange light) : caution;
3. Horizontal (red light) : stop.

As we saw in the preceding paragraph, the absolute signals are usually accompanied by a call on signal, consisting of a short arm placed below the arm or the two arms of the absolute stop. The American railways have thought it advisable to make the difference between the permissive and the absolute signals more definite by using in most cases the following arrangements :

Daylight aspect. — The permissive semaphore arms end in a point (fig. 6); the absolute semaphore arms are cut off square (fig. 7).

Night aspect. — The semaphore signals shew at night a green light, an orange light, or a red light on each of the three position arms and the distinction between the permissive and absolute signals is given by :

— in the case of a single permissive arm, by adding below the arm a red « marker light » placed diagonally in regard to the arm light;
— in the case of two permissive arms, by the respective setting of the lights of each arm which are placed diagonally on the post.

All the lights of the absolute signals are on the other hand placed in line one above the other.

Figures 8 and 9 shew the appearance of the various semaphore signals. The arms are usually red with a white chevron or band. Some systems, and in particular the Pennsylvania, use the yellow arms with black chevron or band.

Daylight signals. — Daylight signals give the same indication by day as by night and follow the same principles as the semaphore signalling, *viz.:*

— use of three indications : line clear, caution and stop;
— use of call on signal;
— grouping of several three indication signals on one post to shew the speed to be observed when running through junctions;
— distinction between permissive and absolute signals by the position of a marker light or by the relative position of the lights of the two superimposed signals.

The American railways use two types of daylight signals : signalling by means of coloured lights and signalling by means of the position of the lights.

The coloured signals shew as a rule by day or by night the same indications as those given by the lights of the semaphores, that is to say, green for line clear, orange for caution, and red for stop. The different lights are carried on a panel of various shapes on which the light for the most important indication alone is illuminated (fig. 10).

The panel plays the same role as a three position semaphore arm. The posts carry therefore as many panels as they would carry semaphore arms in the case of semaphore signalling. Figure 11 shews, as an example, the appearance of the signals in the Chicago and North Western system.

In signalling by means of the position of the lights, the different indications are given no longer by the colours, but by the arrangement of the lights which are also slightly tinted yellow.

The three indications of the panels are (fig. 12) :

— line clear, a vertical line of lights;
— caution, a line of lights at 45°;
— stop, a horizontal line of lights.

Occasionally a fourth position is used in which the lights are arranged at 45°

Fig. 6

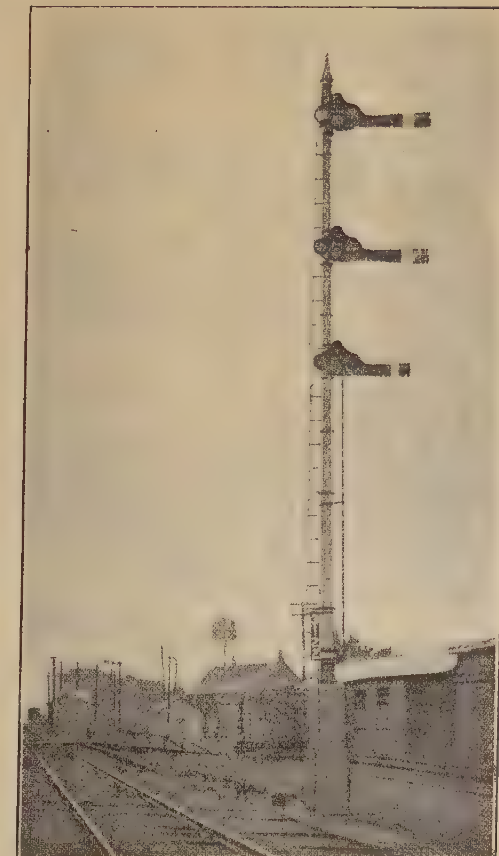
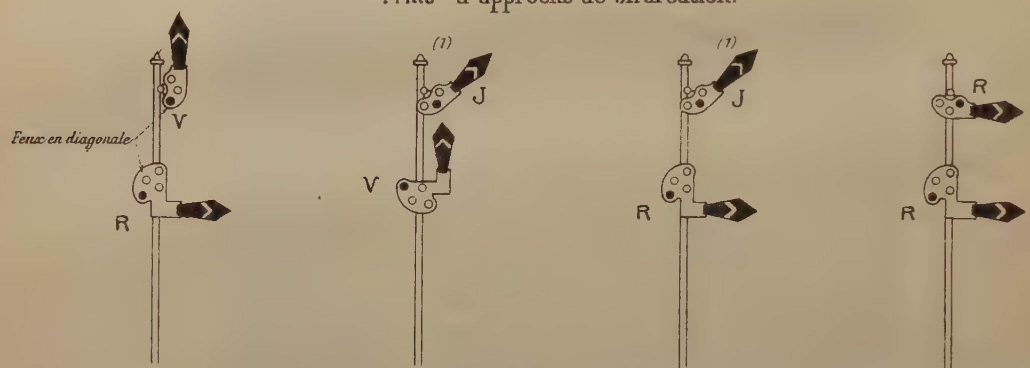


Fig. 7.

Signal à 3 positions.

Position "Voie libre" Position "Avertissement" Position "Arrêt permissif"

. Mât d'approche de bifurcation.



Position "Voie libre" · Approche d'une bifurcation à franchir à vitesse réduite (Branche déviée) Position "Avertissement" Position "Arrêt permissif"

Fig. 8. — Semaphore permissive signals.

Explanation of French terms in figures 8 and 9 :

Approche d'une bifurcation à franchir... = Approaching a junction to be passed at reduced speed branch line). — Feux alignés = Lights in line. — Feu de repère = Marker light. — Feux en diagonale = Lights set diagonally. — J : jaune orangé = Orange. — M d'approche de bifurcation = Junction outer signal post. — Mât d'arrêt absolu = Absolute stop signal post. — Mât de bifurcation = Jun tion signal post. — Position « Arrêt absolu » = « Absolute stop » position. — Position « Arrêt permissif » = « Permissive stop » position. Position « Avertissement » = « Caution » position. — Position « Avertissement » (branche déviée = « Caution » position branch line . Position « Avertissement » (branche directe) — « Caution » position (main line). — Position « Faible vitesse » = « Slow speed » positio — Position « Faible vitesse et marche prudente » = « Slow speed at caution » position. — Position « Voie libre » = « Line clear » position. Position « Voie libre, grande vitesse » branche directe = « Line clear, full speed » position (main line). — Position « Voie libre, vites réduite » (branche déviée) = « Line clear, slow speed » (branch line). — R : rouge = Red. — Signal à 3 positions = Three position sign — Signal de franchissement = Call on signal. — V : vert = Green.

(1) The indication « approaching a junction to be passed at reduced speed » cannot be given at the same time as th « caution » indication which is given greater importance.

Fig 9. — Absolute semaphore signals.

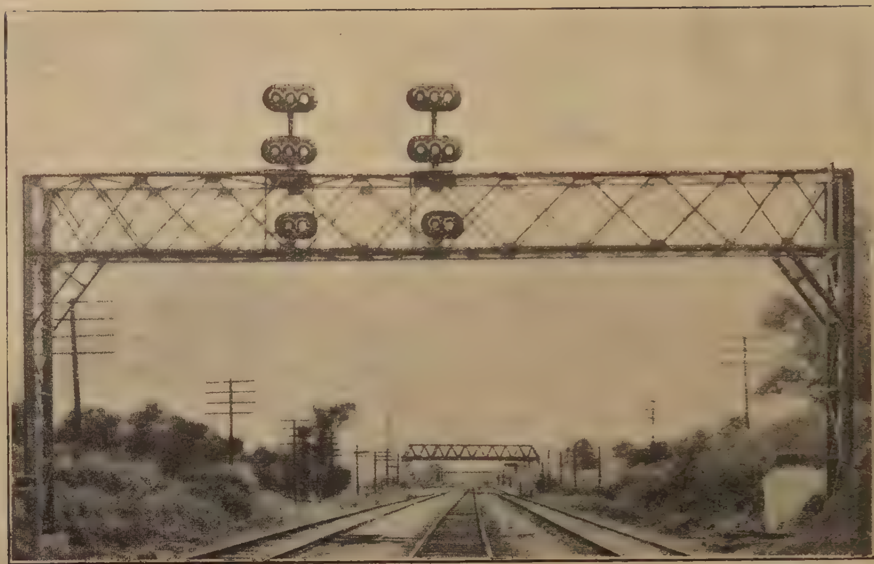


Fig. 10.

symmetrically with regard to the caution position.

The two American systems using position light signals are, excluding certain unimportant sections, the Pennsylvania and the Norfolk & Western. Figure 13 shews the appearance of the signals on the Pennsylvania system on which they were first introduced.

It is interesting to note that new signals utilising both the colour and the position of the lights, have appeared under the name of « coloured position signals » and in particular on the Baltimore & Ohio System : 480 km. (298 miles) of lines having been equipped in this way at the 1 January 1927.

Shunting signals. — In addition to the above signals, the American railways use shunting signals. These signals give two or three indications (caution and stop : or line clear, caution, and stop). They are of small size and placed on the ground level (*dwarf signals*). They are used in the following conditions :

— placed on service lines, they enable the movements giving access to the main lines to be controlled;

— placed on the main lines they enable the routes to be divided and setting back operations to be controlled.

The small size of these signals has the double advantage of preventing any confusion with the usual signals governing the passing trains, and of making it very easy to install them.

A number of the large terminus stations in the United States are equipped with nothing but shunting signals.

III. — Placing and use of signals.

Spacing of trains. — The automatic signals on most of the systems shew « line clear » when the track circuit is unoccupied.

The use of the « overlap » system, which consists in fitting beyond each signal a short insulated section which has to be clear before the preceding signal can be taken off, is exceptional.

The length of the sections, on lines with heavy traffic varies round about 1 mile.

Protection of the small stations and points in the running lines. — The small stations and points in the running lines are protected by setting to danger the preceding permissive signal S (fig. 14) which is at danger when :

1. the section SS′ is occupied;
2. any permanent way appliance is in such a position that the continuity of the main line is broken.

The first condition is given by the action of the track circuit itself, the second by means of electric commutators placed on the levers controlling any permanent way appliances, and in particular any point. This arrangement makes it possible to interlock all the appliances in the station with the signals, although the levers may be outside it.

When S goes to danger, no train can arrive other than at reduced speed. The train is stopped if necessary by hand signals.

When a train leaves a holding or service siding, the trainmen ought to be given an indication as to the position on the main line. If it is only a question of giving them information as to the occupation of the line beyond the points, all that is required is to put up a section signal soon after the outlet from the holding siding or avoiding loop. If it is a question of giving them information at the same time on the state of occupation of the main line before the points, it is the practice to place on the holding siding or avoiding loop near the junction with the main line a miniature signal known as an « *occupation indicator* » which repeats the state of the track circuit of the main line both in front of and beyond the points. This indication gives information in particular as to the occupation of the section lying between the points and the signal S′ and by placing this signal some distance away enables the signalling of the main line to be simplified.

Interlocked signal boxes. — The protection of the area of the interlocked boxes is assured by absolute signals giving three indications, generally with a call on signal in addition, under the control of the signalmen.

Let us consider an absolute signal S_2, preceded by a permissive signal S_1, used as a caution signal. Let S_3 be the first permissive signal situated beyond the area of the interlocked box (fig. 15). The signal S_2 is semi-automatic and operates in the following way : the signals S_1 and S_2 are normally the first at caution, the second at danger : when a train is offered, the signalman of the box takes off these signals if nothing prevents it.

As soon as the first pair of wheels reaches signal S_2, it goes to danger. The signalman of the box confirms the movement by the lever of signal S_2 and the signals cannot be taken off again unless :

1. there is nothing in the interlocking to prevent the lever S_2 being reversed;
2. the section S_2 S_3 is empty.

If the first condition only be realised, the lever of signal S_2 can be reversed, but the track circuits keep the signal at danger. On the other hand, the call on signal can actually be set to clear.

If only the second condition be realised, the levers of signal S_2 and of the call on signal are held in the normal position by the action of the interlocking.

IV. — American regulations for the automatic block.

Before setting out the principles of the American automatic block regulations, it

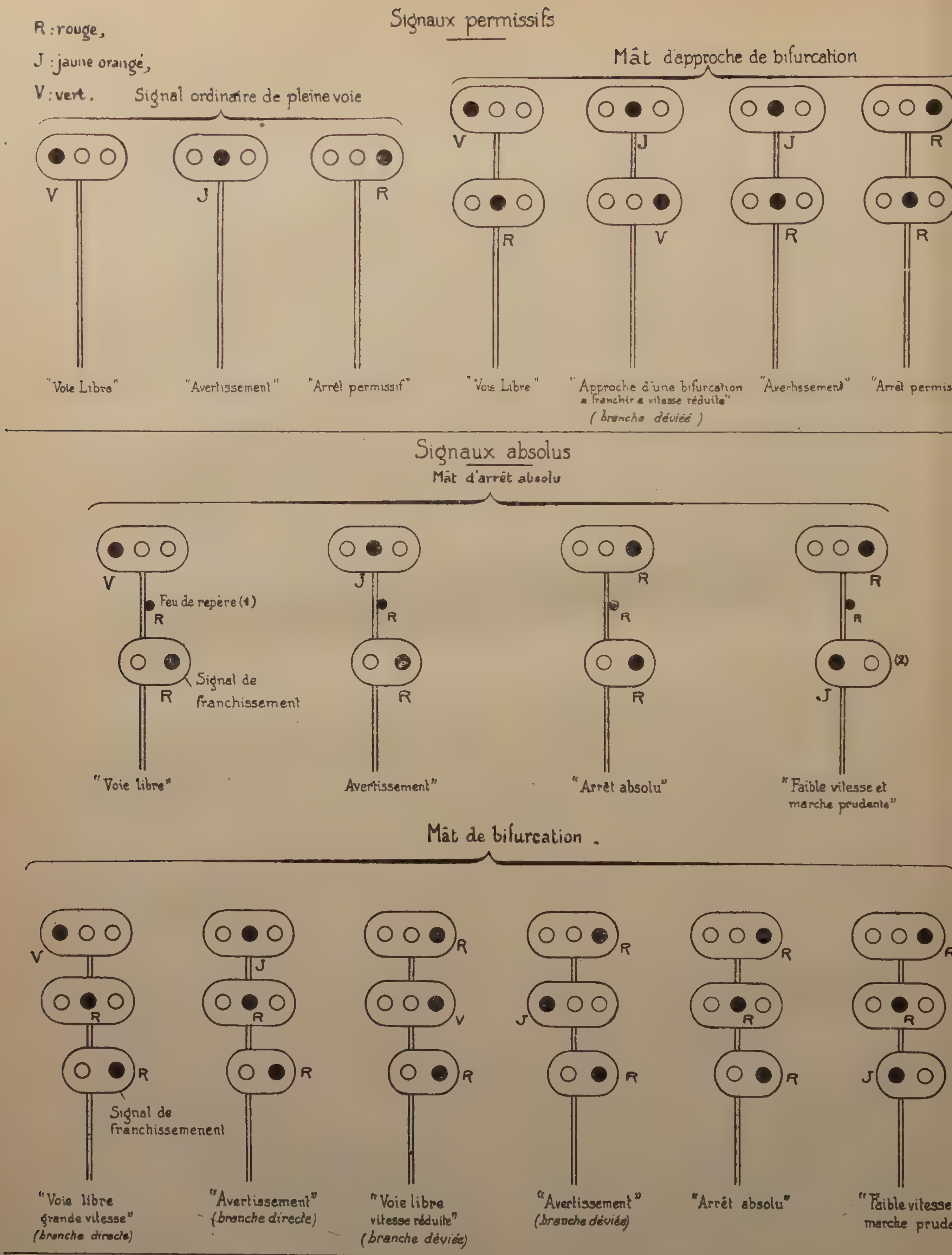


Fig. 11. — Daylight colour signals (Chicago & North Western Railway).

(1) The marker lights are carried on the absolute signal posts and not on the permissive.
(2) The « call on » signal gives the indication « slow speed and caution » but not the indication « slow speed ».

Fig 12.

Explanation of French terms in figure 11 : « Approche d'une bifurcation à franchir à vitesse réduite » (branche déviée) = Outer signal at a junction to be taken at reduced speed (branch line). — « Arrêt absolu » = « Absolute stop ». — « Arrêt permissif » = « Permissive stop ». — « Avertissement » = « Caution ». — « Avertissement » (branche directe) = « Caution » (main line). — « Faible vitesse et marche prudente » = « Slow speed and caution ». — Feu de repère = Marker light. — J : jaune orangé = Orange. — Mât d'approche de bifurcation = Outer signal post at junction. — Mât d'arrêt absolu = Absolute stop signal post. — Mât de bifurcation = Junction signal post. — R : rouge = Red. — Signal de franchissement = Call on signal. — Signal ordinaire de pleine voie = Ordinary signal for running lines. — Signaux absolus = Absolute signals. — Signaux permissifs = Permissive signals. — V : vert = Green. — « Voie libre » = « Line clear ». — « Voie libre grande vitesse » (branche directe) = « Line clear, high speed » (main line). — « Voie libre vitesse réduite » (branche déviée) = « Line clear, reduced speed » (branch line).

is as well to point out that there is a two way method of communication between the driver and rear guard on the trains. This communication is obtained :

— from the driver to the guard — by means of the engine whistle;

— from the guard to the driver — by means of a special compressed air pipe running throughout the train which enables the rear guard to operate a special whistle on the locomotive.

In one direction as in the other, communication is made by a code using combinations of long and short whistles. These signals enable in particular :

1. the driver to order the rear guard to go back to protect the train;

2. the guard to order the driver to stop, to start, to increase or reduce speed, etc.

All the trainmen in cases of emergency are allowed to make free use of this means of communication, and so can take effective steps to ensure safe working.

The most important difference between the French and American regulations lies in the duties of the head guards. In France, except in particular instances, the head guard has hardly any responsibility except when out on the line. In the stations, the inspector or employé on duty controls the train movements and makes all necessary arrangements for carrying out such movements and for safety.

In the United States, the only men at

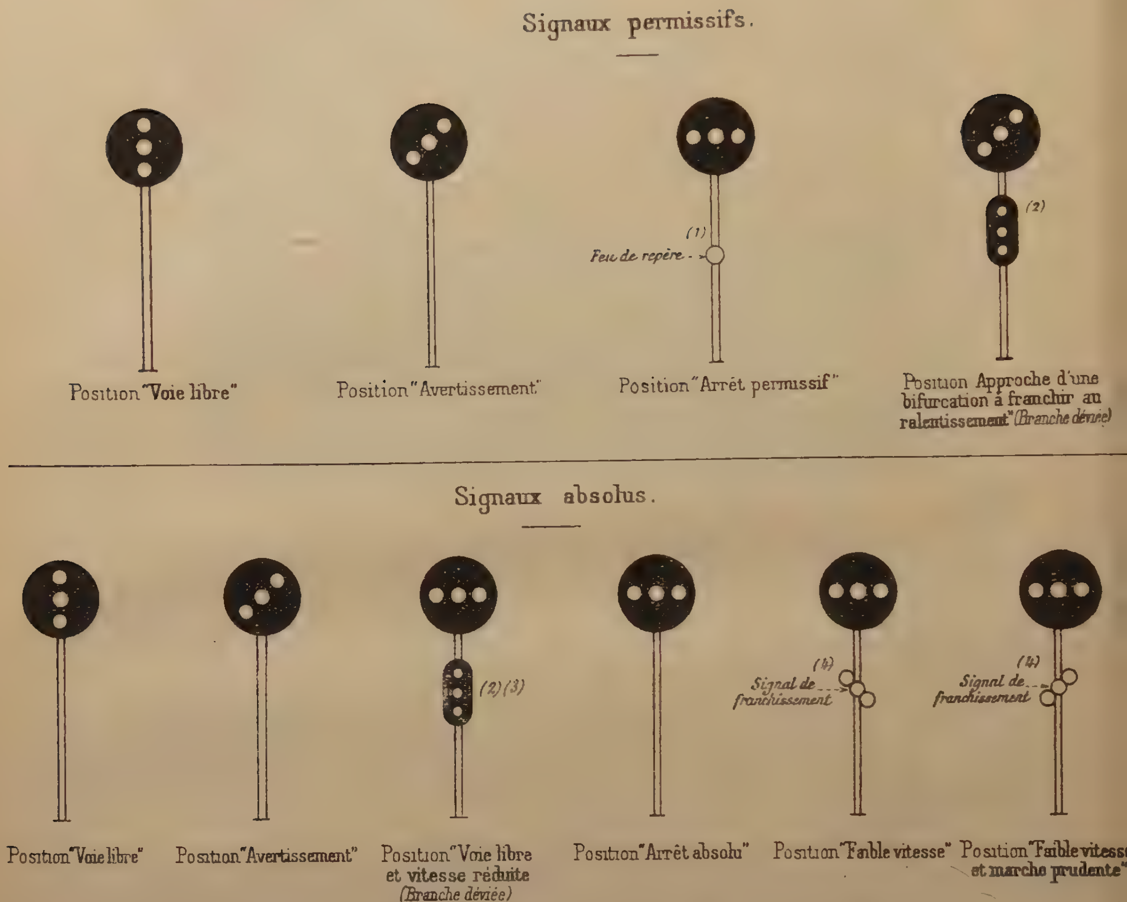


Fig. 13. — Daylight position signals (Pennsylvania Railway).

Explanation of French terms ;

Position Approche d'une bifurcation à franchir au ralentissement (branche deviée) = Approaching a junction to be passed at redu speed (branch line), — Position « Arrêt absolu » = « Absolute stop » position. — Position « Arrêt permissif » = « Permissive sto position. — Position « Avertissement » = « Caution » position. — Position « Faible vitesse » = « Slow speed » position. — Position « Fa vitesse et marche prudente » = « Slow speed at caution » position. — Position « Voie libre » = « Line clear » position. — Position « V libre et vitesse réduite (branche deviée) = « Line clear, reduced speed » position (branch line). — Signaux absolus = Absolute signals Signaux permissifs = Permissive signals.

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(1) The marker light on permissive signals is put out whenever the signal is not at stop.

(2) The difference between the permissive signal post approaching a junction and the absolute junction signal po both of which carry two panels, is solely due to the kind of indication given by these signals.

(3) No provision is made for the position signal to give the indication of the speed to be observed when it gi the caution indication.

(4) In the case of absolute stop, the call on signal is extinguished.

the stations taking any active part in the movement of trains are the signalmen at the interlocked signal boxes. The responsibility of this staff is furthermore

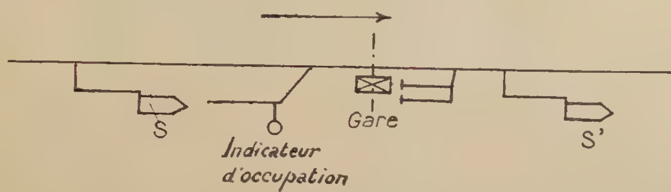


Fig. 14.

Explanation of French terms : Gare = Station. — Indicateur d'occupation = Line occupation indicator.

limited to the zone covered by the box and to the correct working of the signal apparatus.

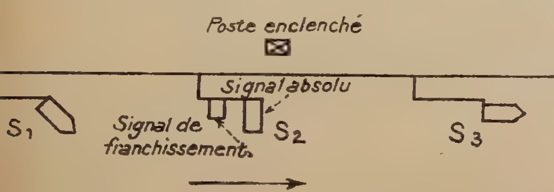


Fig. 15.

Explanation of French terms : Poste enclenché = Interlocked signal box. — Signal absolu = Absolute signal. — Signal de franchissement = Call on signal.

The head guard is responsible for doing all work in connection with his train between stations as in them. In particular all shunts outside the interlocked area, such as in smaller stations, are made under his orders and under his responsibility. The head guard ought therefore to be given information as to the movement of trains, and to get instructions as to the work done at holding sidings, on passing times, etc.

The train dispatcher is instructed to give the guard this information. The dispatching system is in fact quite general in the United States : it presupposes the subordination of all the traffic operating staff to the dispatcher who issues the definite orders. Communication between the guards and the dispatcher is assured directly by telephone or by the intermediary of the station masters who limit themselves to transmitting the orders received and to repeating them to the train crews by written orders or by means of signals. The first solution — written orders, called « *train orders* » — has formed for a considerable time, for reasons of economy, the most general method of operation. It now tends to give place to the use of the signals which are safer and quicker (1).

Action to be taken at a stop signal. — An absolute signal cannot be passed unless authorised. The authority is given by the employé who operates the signal, or by an employé conversant with the state of occupation of the lines.

On the other hand, a permissive signal at stop can be passed. The driver is allowed after he has stopped to go forward at caution into the section blocked. He should, according to the regulations « expect to find in the section a train, a broken rail, some obstacle, or points wrongly set ».

Protection of trains. — The rear guard, in order to protect his train, is provided with : during the day, a red flag, detonators and flares; by night, a lamp, detonators and flares. The flares consist of a powder similar to that in Bengal lights

(1) When operating with « *train orders* » the trains to which the written orders are to be given are stopped by special signals quite independent of the signals described in this article.

burning with a red flame, made up in tubes; they burn for several minutes.

The American regulations provide for all trains to be protected every time they are stopped on a main line outside the protection of absolute signals. The rules are very definite and would seem likely to result in guards missing their trains or in delays in operating. The regulations allow however for this protection not being carried out in all cases by only requiring it when « the circumstances are such that a train may be overtaken by a following train » a sufficiently vague expression upon the meaning of which the American railways have not been too insistent.

Under this reservation, the guard should, when the train stops « *go back sufficiently far to protect his train* ». When he has gone the necessary distance, where he should stay until he is recalled by the agreed whistle signals given by the driver, he should place the detonators on the rails, display stop signals and « if the circumstances require it » light a flare.

If the following train arrives before the guard has gone back the proper distance, he should make the fullest use of this equipment, and should not return to his train even if recalled by whistle signal before the following train has been stopped.

When recalled, the guard leaves the detonators and one flare on the track. When he has rejoined his train he gives the driver the signal to start by means of the compressed air main.

The American regulations provide in general for the case in which a slow running train is in danger of being overtaken by a following train. The only precise instruction given in the printed regulations consists, during the night or in poor visibility, in dropping behind the train at suitable intervals, lighted flares. These flares burn for some minutes and are used to warn a train following too closely a train running at low speed.

TECHNICAL CONSTRUCTIONAL DETAILS OF THE AUTOMATIC BLOCK.

I. — Track circuits and relays.

Equipment of the track circuit. — The bonds between the rails in the United States are made of galvanised iron wire, copper steel wire called « copperclad » (a bi-metal wire with a steel core covered with a layer of copper), copper wires, or a mixture of these latter. The length varies from 1 m. to 1.50 m. (3 ft. 3 3/8 in. to 4 ft. 11 in.) according to the size of the fish plates. The diameter, on steam lines, is 4.20 mm. (0.165 inch) for the galvanised iron wire, and 4.12 mm. (0.162 inch) for the copper wire.

Each rail joint has two bonds as a rule so as to maintain the continuity of the track circuit should one of them happen to break. Four wires even are used at certain places, such as crossings, points, etc. The two bonds are placed outside the fish plates and on the inside of the rail. Various arrangements (hooks, clamps, etc.) are used to keep them in place against the rails and prevent them getting out of order (fig. 16).

The bonds in most cases are secured to the rails by means of plugs. These may be of the ordinary type with a single groove in which the end of the bonding wire is placed : in this case the plug is driven into the web of the rail with the groove turned downwards. They may also be of the duplex type with two grooves arranged symmetrically about the axis of the plug (fig. 17), with which pattern the two bonding wires can be fixed to the rail at the same time. The pattern plug is then driven in with the grooves to the sides.

The American companies have taken much trouble to overcome the breaking of bonds : they have tried at the same time to prevent the reduction of mechanical strength and of electrical conductibility caused by rusting and corrosion of the wire and plugs.

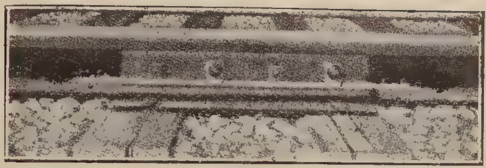


Fig. 16.

Fig. 17.

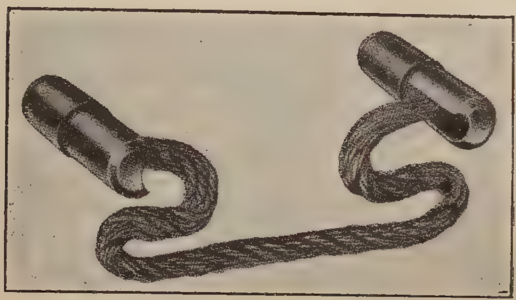


Fig. 18.

Fig. 19.

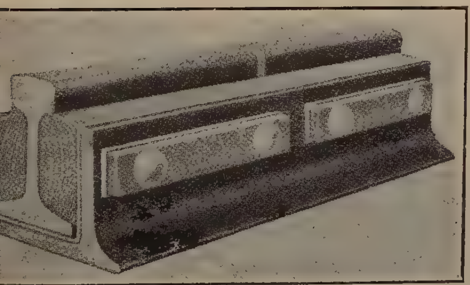


Fig. 20.

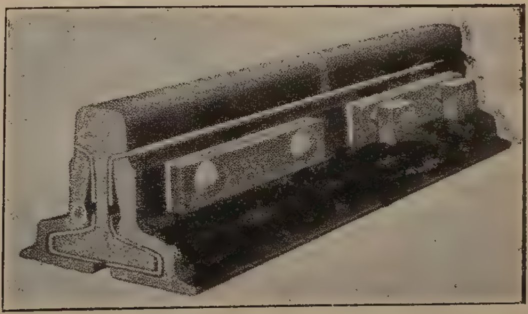


Fig. 21.

Figs. 16 to 21.

The most usual method is to use non-rusting bonds, either of pure iron, zinc covered, fastened with ordinary plugs, or small multi-stranded iron, copper or copper clad cables, giving a large total area. These cables are secured to the rails by means of 9.5 mm. (3/8 inch) plugs. A single bond of this kind is sufficient per joint (fig. 18). This latter method is only used in cases where it is necessary there should be good conductivity locally.

Another method is to use welded bonds (fig. 19) in which a single wire or cable of copper, of varying section, depending on the current intensity in the rails, is welded to the rail head at the ends of each of the two adjacent rails. The copper bonds are of short length and their cost reasonably low. This type of bond only seems to be used on the electrified lines.

The conductors carrying current to the rails from the main supply are either :

— armoured cables;

— cables not armoured or ordinary insulated wires protected by wood trunking. This latter way appears to be more generally used.

The method of connecting up to the rail varies according to the company. Some use jointing boxes, others have given them up, and connect direct to the rails.

All American insulated joints are « supported » which gives them a relatively long life. The two types of joints most frequently used are : the « Weber » joint (fig. 20) which uses wood as insulation, and the « Continuous » using fiber. The American companies prefer the Weber joint from an electric point of view, but the Continuous as regards mechanical construction. For the latter reason, the Continuous joint is largely used where there are no points and crossings : its insulation resistance is ample owing to the good quality of American fibers which have to comply with the stringent specifications of the « American Railway Association » as regards their density, mechanical strength, electrical resistance, and their impermeability.

The inductive connections on lines with electric traction by continuous current have an iron core. The weight of copper used is thereby reduced : on the other hand, they have the defect of being magnetised by the currents set up by the difference of intensity between the return currents in the two rails. The connections are generally arranged so that their reactance lies within reasonable limits with an out of balance of 10 to 20 %.

When the traction is by alternating current, iron cored connections are also generally used. The frequencies generally employed in this case are : 25 periods for the traction current and 60 for the signalling current.

Track relays. — Kinds and action. — The relays may be divided into five types :

Continuous current relays :

- neutral type;
- polarised type.

Alternating current relays :

- ordinary type with one element;
- ordinary type with two elements;
- frequency type.

It should be remembered that the continuous current polarised relay has two armatures : a neutral armature which acts like that of a neutral relay and a polarised armature which acts as selector between the circuits controlling the « line clear » and « caution » positions of the signal. These relays can thereby give three indications.

As regards the alternating current relays, they are described as « single element » when they do not make use of any auxiliary supply of local current, and as « double element » when they have a « track winding » fed by the track circuit, and a « local winding » supplied by a local supply of current. This latter type

of relay can be designed to give two or three indications.

Finally, the « frequency » type relays do not function effectively except above a determined frequency, namely that of the signalling current.

These relays will not be described as they are already known on the French railways : the upper contacts controlling the setting of the signals to line clear are however of the carbon-silver type with which any possibility of fusing is avoided.

As is well known, the track relays repeat the state of occupation of the track circuit. They should be « energised » when the circuit is unoccupied and « de-energised » when occupied. The problem of the action of the track relay is therefore covered by considering its electrical characteristics, taking into account the variations of the condition of the track circuit to which it is connected.

The characteristic values on which the American measurements of track relays are based are :

1. The intensity of the excitation current (*pick up*);
2. The intensity of the working current (*working*);
3. The intensity of the release current (*drop away*).

The *pick up* intensity is that of the current which should flow through the track winding E to displace the moveable part (armature, rotor, blade, etc.) to the points where the contact fingers come against the carbons (upper contacts) without exercising any pressure on them.

If the intensity of the current flowing through E is increased above the excitation value, the moveable part of the relay continues to move : the contact fingers exert a growing pressure on the carbons under which they yield more and more. Their ends at the same time move across the surface of the carbon and ensure by a rubbing action a really good contact. The *degree of work* is the value reached by the current when the moveable part gets to the end of its travel.

The winding E being originally traversed by the working current, let us suppose the intensity of the current is reduced progressively. The force acting on the moveable part decreases as the intensity falls : the bending of the contacts diminishes little by little until they no longer exert any pressure on the pieces of carbon. At this moment the electro magnetic motor couple is exactly equal to the resisting mechanical couple exerted on the moveable part by the return gear; the corresponding value of the intensity in the winding E is that of the *drop away*.

If the current falls still further, the armature is returned to its position of rest, breaking the « upper » contacts and closing the « lower » contacts.

Having stated these definitions, the way in which a track relay in a track circuit acts can be accurately described. These conditions are three in number :

1. The normal intensity of current in the relay should be greater or equal to the working current; it is as well, furthermore, not to exceed this value by too much, as too intense a current through the bobbins of the relay can ultimately upset their proper working;

2. The intensity of current through the relay should drop below the drop away value as soon as the track circuit is shunted by any vehicle;

3. The intensity should have a value higher than the excitation value, as soon as the track circuit is clear.

These conditions are the more easily obtained when the relay is designed with a lower excitation intensity and with the ratios $\frac{\text{drop away}}{\text{working}}$ and $\frac{\text{drop away}}{\text{pick up}}$ closer to unity. The values of the pick up and the above ratios are very important charac-

teristics as they measure the facility with which a relay becomes de-energised and energised afresh.

The following table gives the characteristic values of the *continuous current neutral relays* made by the General Railway Signal Co. to the specifications of the American Railway Association.

	Working.	Drop away.	Pick up.
2 ohm-relays	0.132 ampere.	0.044 ampere.	0.088 ampere.
4 ohm-relays	0.090 ampere.	0.030 ampere.	0.060 ampere.

Generally speaking, the inspection clauses require the minimum drop away to have a value equal to at least 50 % of that of the maximum pick up.

As regards the *alternating current relays,* the American Railway Association specifications are less difficult. They require the ratio $\frac{\text{drop away}}{\text{pick up}}$ to be not less than 45 %. In fact, the value actually is often as high as 78 to 90 % : the corresponding test for a two-element relay ought to be made by only reducing the tension of the track element, whilst that of the local element is kept at its normal value : in this way the practical conditions are observed. As to the ratio $\frac{\text{pick up}}{\text{working}}$ it should not be less than 50 % and actually often exceeds 75 % : the corresponding test for a two-element relay should also be made by a simple variation of the tension of the track element. Finally all American alternating current relays should work properly when the various tensions are reduced to 85 % of their usual values.

Use of the various types of track circuits and relays. — On electrified lines, alternating current must be used. On the other hand, on steam lines, a choice is possible, *a priori,* between various types of track circuits and relays.

As a general rule, the American companies consider continuous current track relays have the following advantages :

— low purchase cost;
— easy upkeep;
— accurate regulation;
— very simple fitting;
— much higher mechanical efficiency than alternating current relays (their consumption of energy is, in fact, a sixth or an eighth).

They have two defects, however. They cannot be used with primary cells except on moderate length sections, particularly when the ballast is not very good. In fact, the cells have a low electromotive force, and the high cost of current limits the number connected in series, the loss of energy through the ballast becoming rapidly prohibitive. Continuous current relays are in addition readily influenced by currents other than those of the track circuit.

As regards *continuous current relays* of the neutral type, the American railways attach the greatest importance to the correct selection of the resistance of their winding.

The 4 ohm-relays have been for a long time the most frequently used in the United States. At the present time, however, there is a tendency to use 2 ohm-relays with caustic soda cells (electromotive force 0.65 volt).

The 2 ohm-relays are shewn by calculation, confirmed in use, to be less sensitive to leakage of current through the insulated joints. They can function satisfactorily with a lower ballast resistance than that required by the 4 ohm-relays. The use of the 2 ohm-relay makes it possible to lengthen the track circuits, everything else being the same, provided a suitable resistance is inserted between the battery and the track. Finally, the

consumption of energy by the 2 ohm-relay is about 50 % lower when the track is occupied : if the track is unoccupied the consumption is also lower provided the ballast resistance is not too great.

The current practice in the United States is to use the 4 ohm-relay when the track circuit is fed by accumulators or when fed by caustic soda cells with the ballast conditions good. The 2 ohm-relay is chiefly used on long track circuits with soda cells and with a low ballast resistance.

The use of continuous current polarised relays is still exceptional. They have the advantage of making it unnecessary to use line wires and relays, but they are said to be subject to frequent defects due, it would appear, to variations in the magnetisation of the permanent magnet.

The fitting of *alternating current track circuits and relays,* essential for electrified lines, is extending also on the steam traction lines when there is any fear of stray currents.

The relays with one element are only used on track circuits of less than about 350 m. (383 yards) length. In the case of two-element relays, circuits up to 3 to 4 km. (1.86 to 2.49 miles) are in use. Amongst such, the three-position relays have the advantage of making it unnecessary to use line circuits and relays; they work satisfactorily, but have the defect that if the insulated joints break instead of « stop » they can give a false indication of « caution ».

As regards the frequency relays, their use is generally reserved to lines with alternating current traction.

II. — Description and working of automatic signals.

As we have seen, the American railways use two kinds of automatic signals : *semaphore signals* and *daylight signals.*

Description of the semaphore signals. — The American companies have adopted as standard the three-position automatic signal, working in the upper quadrant. The indications of these signals are given : by day, by the position of the semaphore arm; by night, by the coloured lights (red, orange, green).

The *arms* of the signals (fig. 22) are in enamelled metal, which is easier to maintain and makes the arm much brighter and cleaner looking. They are generally covered with deep red enamel with a white chevron parallel to the point in the case of the automatic permissive signals (1); occasionally they are enamelled light yellow with a black chevron (1). The presence of this chevron, which stands out sharply against the background of the arm and repeats the symmetrical axis thereof, adds to the excellent visibility of the signal indication.

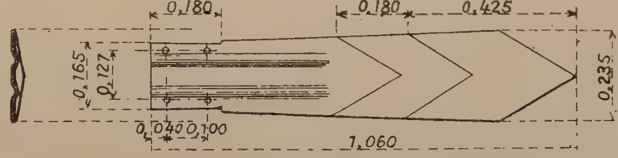


Fig. 22.

The arms are fixed by means of bolts or clamps to the *glass frames* (fig. 23) carrying three convex coloured glasses (A, B and C) which pass in turn before the semaphore light (1). The whole unit of the glass frames and the arm turn

(1) The chevron is replaced by a straight band is the case of absolute signals.

(1) The use of convex glasses prevents « phantom indications » or false indications due to the deflection by the flat glasses of sunlight or of the beams of light from locomotive headlights.

about a pin O, carried on bearings on the signal post as shewn in figure 24. This arrangement gives the arm in its vertical position a slight off-set like a bayonet in regard to the post, and makes the indication of « line clear » very definite.

The signal posts are of various types depending upon whether they are erected on the ground or on brackets or bridges, and whether they have one or several semaphore arms. In the case of a post erected on the ground with one single arm, the pin O round which the coloured glass frame rotates is 7.24 m. (23 ft. 9 in.) above the bottom of the rail (fig. 25). When the posts carry several arms, the lowest arm is always set at this point : the space between two arms being 2.13 m. (7 feet) and only 1.83 m. (6 feet) between an arm and a small call on signal arm.

The lamp which gives the signal indication by night is carried on an adjustable bracket secured to the signal post so that it can be accurately aligned with the signal glasses. The lamp has usually a colourless lens which can be fitted with special devices to spread the beam on curves.

The semaphore arm is driven by an electric motor which on modern signals carries with it the coloured glass frame by means of a simple train of gears without any rods or wires. In order to get this result, the box containing the motors and the whole of the *mechanism* is fastened to the signal post by brackets behind the glass carrying frame (fig. 26) : it is so arranged as not to affect the outline of the signal in any way. A gear of this kind has to comply with the requirements of many specifications : it should put the signal to danger automatically as soon as anything goes wrong with any part, the arm going from line clear to danger in 8 seconds at most. The couple (motor or resistance) which the electric motor should exert on the shaft of a signal fitted with standard signal arm and glass carrying frame is shewn by the curves of figure 27 : curve A represents the variation of the motor couple during the movement from 0° (stop) to 90° (line clear), the curve A′ the variation in the resisting couple in the reverse direction.

Working of the automatic signals. — The motor shewn at M in figure 28 is usually a series type continuous current motor or an asynchronous biphase alternating current motor. It works in the *reverse direction :* that is to say, the coupling of its armature and the semaphore arm acts in both directions : when the windings are under tension, the armature takes the arm to the position « caution » or « line clear »: contrarily, when the arm falls by gravity it takes with it the armature in the opposite direction to the usual way of rotation, an arrangement which allows of electric braking. The coupling of the arm and the motor by means of a train of gears E is not absolutely rigid : to protect the motor and the gears from too sudden stops and too heavy loads when the arm stops at the end of the return movement, the American builders have provided ratchet devices, friction bands on the gear wheels, etc., which give a certain elasticity to the coupling.

The *holding device* D, which keeps the arm at 45° or 90°, the « caution » and « line clear » positions controlled by the action of the track relays, consists of an electro magnet which is excited slightly before the arm comes to the desired position and whose core then locks a drum frictionally driven by the motor shaft. The armature is thereby braked and held as soon as the motor ceases to be under tension.

The *commutator* C (figs. 28 and 29) is the principal controlling device for the different circuits (inductances. armature, holding on device, etc.) ; it is, generally, composed of a drum of insulating material connected by a train of gears to the pin of the semaphore arm : for

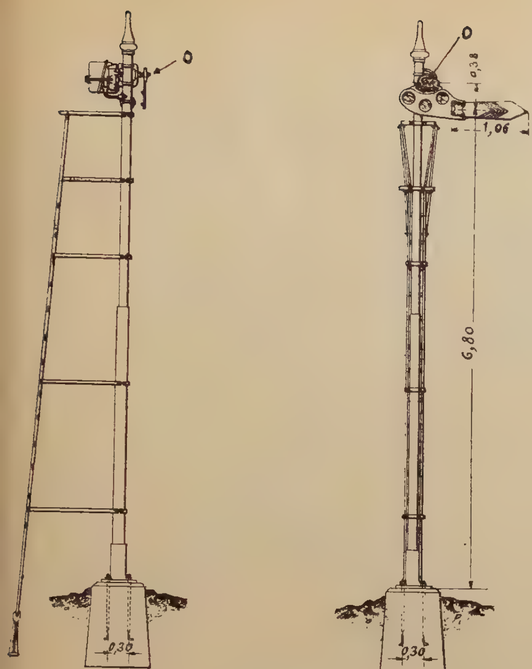


Fig. 24.

Explanation of French terms in figures 23 to 25 : Axe = Axis. — Base du rail = Base of the rail. — (*a*) Ecartement de l'axe, etc. = Spacing of the axis of the pole to the axis of rotation of the signal arm, maximum : 124 mm. (4 7/8 inches), minimum ; 92 mm. (3 5/8 inches). — Jaune = Orange. — Pied de tube = Bottom end of the tube. — Rouge = Red. — Vert = Green.

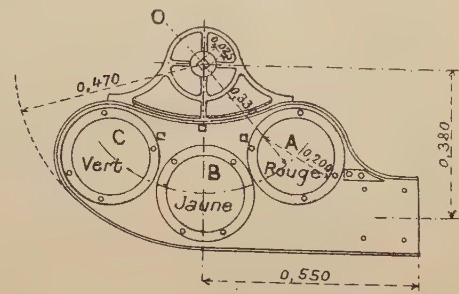


Fig. 23.

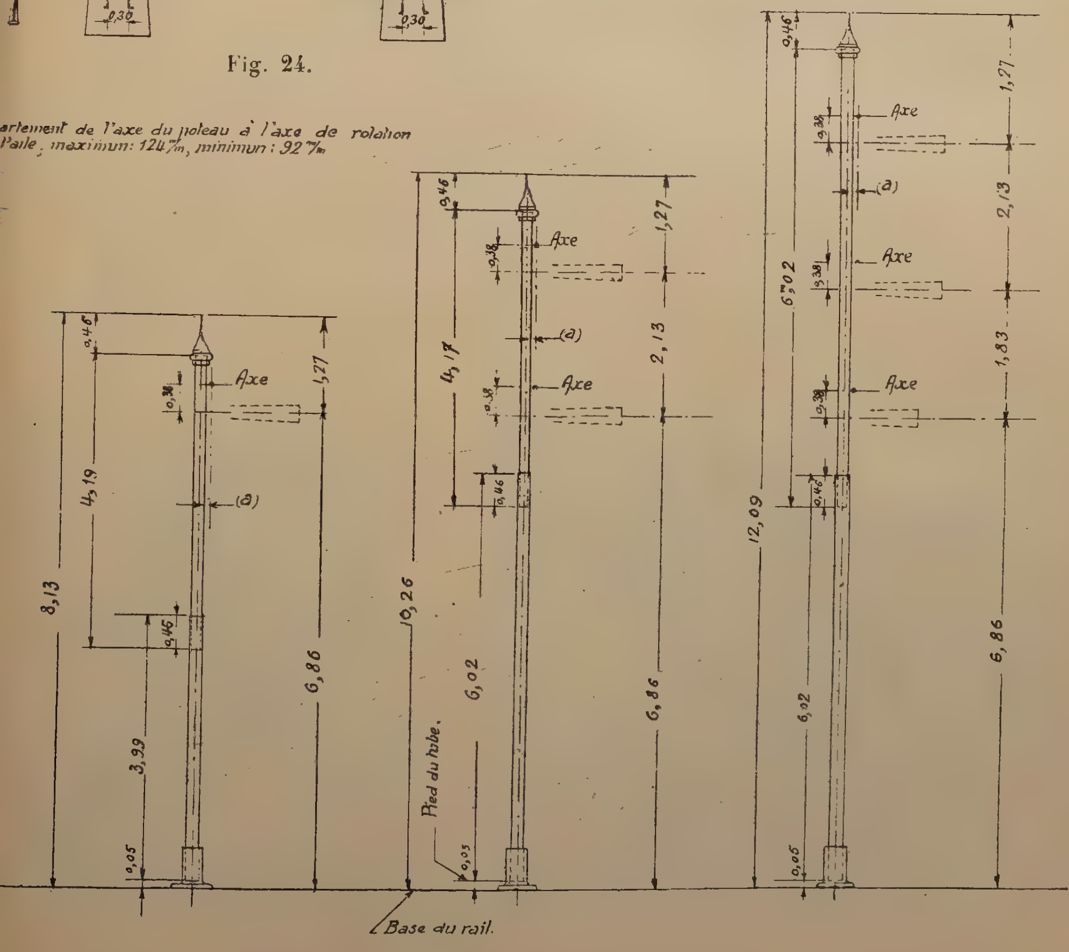


Fig. 25.

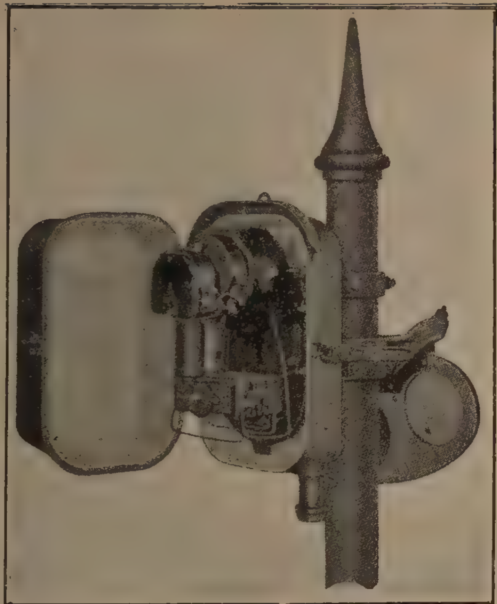
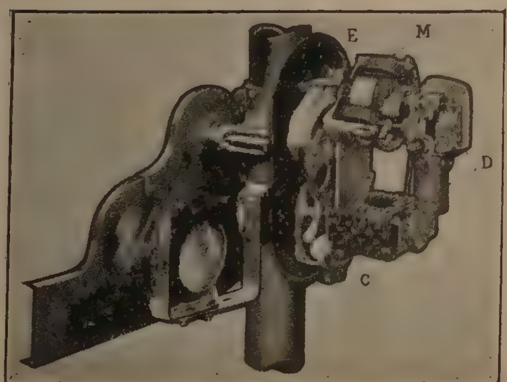


Fig. 26.



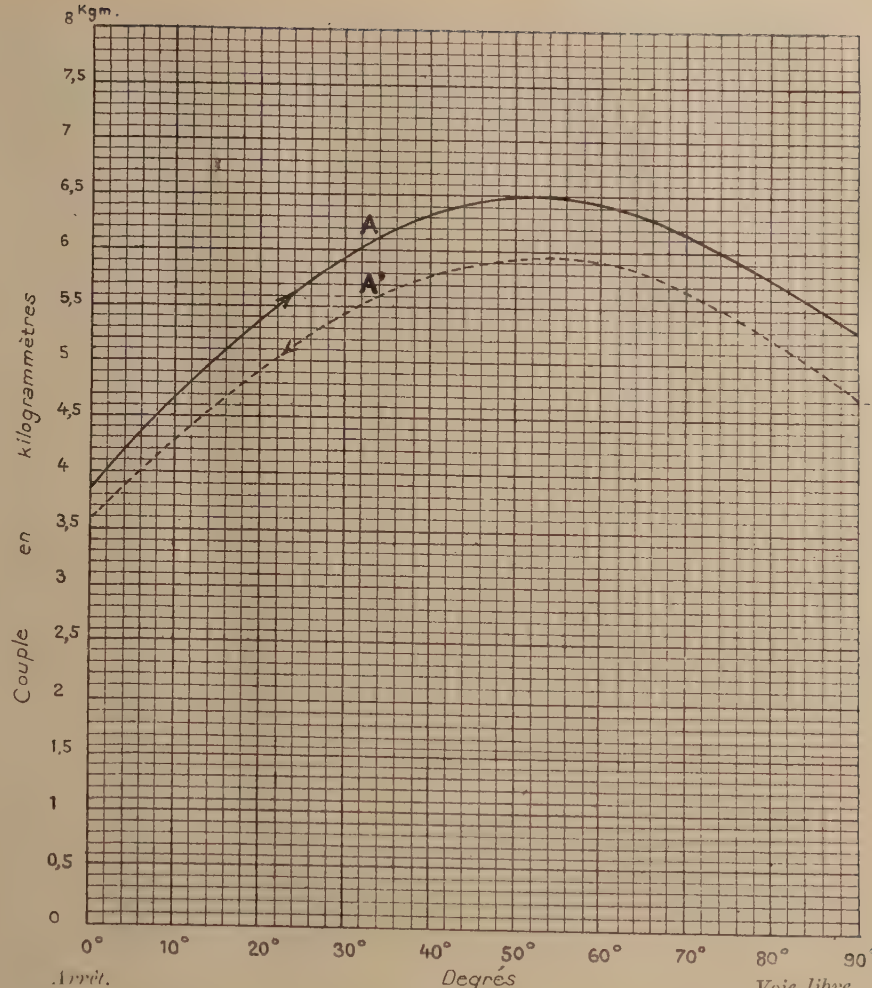


Fig. 27.

Explanation of French terms : Arrêt = Stop. — Couple en kilogrammètres = Couple in kilogrammetres. — Degrés = Degrees. — Voie libre = Line clear.

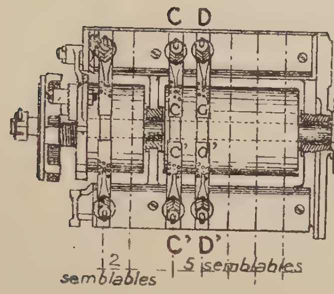


Fig. 29.

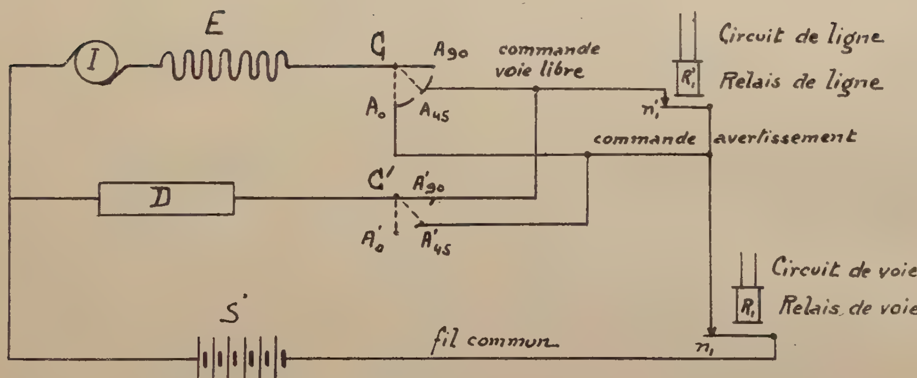


Fig. 30.

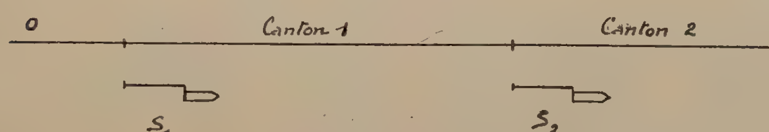


Fig. 31.

Explanation of French terms in figures 29 to 31 : Canton = Section. — Circuit de ligne = Line circuit. — Circuit de voie = Track circuit. — Commande avertissement = Caution control. — Commande voie libre = Control for line clear. — Fil commun = Common conductor. — Relais de ligne = Line relay. — Relais de voie = Track relay. — Semblables = Duplicates.

every position of the arm there is a well defined position of the commutator drum. The drum carries in the form of segments of suitable length, conductor strips which, at the desired moment, open or close by means of the contacts *c*, *c'*, *d*, *d'*, etc., the various circuits ending at the terminals C, C', D, D', etc.

For example, figure 30 shews in their essential features *the control circuits of a continuous current motor* operating a signal S_1 (fig. 31). I shews the armature, E the windings of the motor, D the holding on electro magnet, C and C' diagrammatically the commutator; and A and A' the conductor spindles which turn at the same time as the semaphore arm, and take up the positions A_0, A_{45}, A_{90}, etc., when the arm is respectively at 0° (stop), 45° (caution) or 90° (line clear) ; *s'* indi-

cates the continuous current supply (battery of cells or accumulators); R_1 the track relay of section 1; R'_1 is a « line relay » fed by a « line circuit » and its armature reproduces at S_1, the position of the armature of the track relay of section 2.

If a train runs into section 1, R_1 is de-energised : the various control circuits (motor and holding on) are broken by the opening of contact n_1, the arm falls by gravity taking with it in its backward movement the motor armature and the commutator which go to A_0, A'_0.

If the train clear the section 1 by going into section 2, R_1 is energised and R'_1 de-energised — the contact n_1 closes, n'_1 opens. The control circuits of the *caution* position being in this way closed, the windings E are put under tension by A_0 and the motor takes with it the arm until the commutator gets to the position A_{45}, A'_{45}; at this moment the supply to the windings is cut off at A_{45} and the motor stops; the holding on device being energised at A'_{45} the arm is held at « caution ».

If the train clear section 2, 1 remaining empty, the relay R'_1 is energised : n' closes; the commutator being at A_{45}, A'_{45}, the windings E are again excited and the motor moves the arm to the position « line clear ». The motor then stops, the excitation circuit of E being broken at A_{90}; on the other hand, the holding on electro magnet is energised at A'_{90} and holds the arm at « line clear ».

In the United States, as would be expected, a great many different ways of fitting up signals are to be found, according to the type of motor used, the method of connecting the signals (two position track relays, line relays, alternating or continuous current : continuous current relays of the polarised type, or three position alternating current type which combine the functions of the track and line relays assembled in the way described above). The principle of the working of the automatic semaphores is none the less the same in all the different cases.

The semaphores designed in accordance with the above principles work remarkably well on thousands of kilometres in the United States; doing away with all rodding or wires between the motor and the arm avoids many working failures; freezing up is almost entirely avoided thanks to the care given to the pins and bearings which are kept properly tight and well lubricated, and also to the maintenance policy followed by the American railways. It may be pointed out that some of the American railways have completely overcome failures due to freezing up by sealing up the motors from October to May after having dried out the gear boxes and carefully greased the pins.

General remarks on daylight signals. — As we have already noted, the daylight signals give the same indication by day as by night. They consist of panels carrying a number of separate lights : a red light, an orange, and a green, for the coloured signals, three groups of yellow white lights for the position signals.

The optical devices used in the *lamp units* should prevent « phantom indications » due to the reflection of rays from an outside source (sun near the horizon, locomotive head lights, etc.) being given. This condition, as a rule, prevents reflectors from being used in the daylight signals.

In the United States, daylight signals on straight lines with high speed trains must be visible 1 200 m. (1 300 yards) on a clear day with the sun near the zenith, so that the beam of light has to have an average intensity of 5 to 6 000 candles. To get this distance without unduly increasing the consumption of the lamps, it is necessary to allow the beam only a small spread, and this leads to the use of lamps with a very compact filament placed at the focal centre of the optical system. A lamp of this kind using

only 18 watts will, according to the makers, give a luminous intensity of 20 000 candle power on the axis of the beam, whereas an ordinary commercial lamp of the same wattage only gives 500 candle power.

The beam emitted by the daylight signals, having a small angle (3° about the axis as an average), it is necessary :

— to fit the lamp units with prismatic lens to spread the beam horizontally on curves;

— to provide means for sighting the signals close up so that a driver stopped at the signal can read the indication given;

— to build the signals so that they can be very accurately set by horizontal and vertical adjusting devices;

— to place the lights as often as possible on a level with the drivers' eyes : this being the reason the American companies place as a rule the lowest light 3.60 m. to 4.30 m. (11 ft. 10 in. to 14 feet) above rail level.

Coloured daylight signals. — Most of the coloured daylight signals in use on the American railways are made up of panels carrying three lamp units : a red, an orange, and a green. These three lights are arranged according to the type of signal, in a horizontal straight line, in a vertical straight line, or in a triangle (fig. 32).

The *coloured lamp unit of the General Railway Signal Company,* as an example, is shewn in figure 33. The light itself is a double concentrated tungsten filament. The double filament is set in the focal centre of an optical system formed by two stepped lenses : the outer in clear glass 204 mm. (8 inches) diameter and 100 mm. (3 15/16 inches) focal length; the inner is in coloured glass, 140 mm. (5 1/2 inches) diameter, and its focal length may be as short as 12.50 mm. (1/2 inch). Thanks to this wide angle, the lamp can be placed very close to the inner lens which collects practically all the rays given by the front half of the bulb. The two lenses are carried by cast-iron frames very carefully fitted, so that the two optical axes always coincide. The whole system, made up of the two lenses, the lamp and the lamp carrier, is built as a unit which can be removed as a whole. Either of the two lenses can be renewed without in any way upsetting the optical adjustment of the system.

The position of the lamp carrier in relation to the lenses and that of the filaments with reference to the caps of the bulbs, is carefully adjusted at the works. In this way the filament can be relied upon to be exactly at the focal centre of the lens, and a bulb can be replaced outside without any re-setting of the optical system being required.

The *lamps with concentrated filaments* usually supplied by the « G. R. S. » are made for the following tensions and consumptions :

8 volts	.....	10 watts,
8 —	.....	18 —
10 —	.....	18 —
10 —	.....	40 —
120 —	.....	30 —

In service the life of the lamps is considerably increased by running them 10 % under voltage : this does not affect the sighting distance appreciably. The approximate values of this sighting distance for a coloured daylight « G. R. S. » signal with lamp units having 204 mm. (8 inch) diameter lenses in bright sunshine on a straight line are given in the following table :

Supply current.	Consumption of the lamp.	Lighting distance of the signal.
10 volts.	40 watts.	1 500 to 1 800 m. 1 640 to 1 970 yards.
10 —	18 —	1 200 to 1 500 m. 1 310 to 1 640 yards.
8 —	18 —	1 200 to 1 500 m. 1 310 to 1 640 yards.
8 —	10 —	750 to 1 050 m. 820 to 1 150 yards.
120 —	30 —	1 200 to 1 500 m. 1 310 to 1 640 yards.

The luminous intensity on the axis after passing through the two clear glass lenses is about 20 000 candle power with an 18 watt-lamp.

Fig. 32.

Explanation of French terms : Panneau circulaire = Circular panel. — Panneau horizontal = Horizontal panel. — Panneau vertical = Vertical panel.

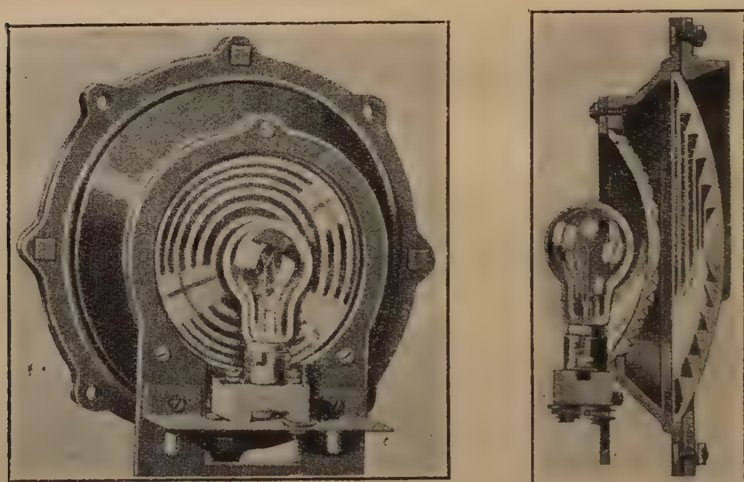


Fig. 33.

The *lenses* in use in the United States for daylight signals are divided into five principal types :

— the « optical » type with interior steps, the most usual, gives a strong beam with little spread;

— the « inverted » type with exterior steps fitted with a protecting glass gives a beam with slightly greater spread;

— the « yard » type gives a beam with a wide spread but of relatively small intensity: it is generally used in marshalling yards;

— the « spreadlite » type or disperser is a compromise between the « optical » and « yard » types; it spreads out the beam fanwise in the horizontal plane and gives a sufficiently powerful beam : it is particularly suited for signals placed on curves;

— the « toric » type with very slight spread is used with daylight signals which have to be visible in daylight from very great distances. A secondary beam should be refracted towards the ground to give good visibility when near the signal.

The outer lens usually supplied with coloured signals is of clear glass: it gives a main beam having an angle of spread of 3° about the optical axis [1], and a secondary refracted beam making an angle of 20° with the horizontal. The inner lens of the « G. R. S. » signals is a coloured glass « inverted » type lens.

The *coloured lenses* supplied by American makers shew a red, green orange, blue, purple, or « moonlight » white. They have to possess certain optical qualities and comply with the various spectrophotometric specifications drawn up by the American Railway Association [2].

Their refraction index should not be lower than 1.5. The lenses and coloured glasses are subjected to a spectrophotometric analysis, the results of which should agree with the figures of the table given below. The first column gives the wave length of the different radiations of the spectrum measured in microns. The other columns shew for each wave length the percentage of the corresponding luminous energy transmitted by the glasses or lenses of the six standard colours.

Wave lengths.	Red glass.	Orange glass.	Green glass.	Blue glass.	Purple glass.	Moonlight white glass.
0.41	0	0	40	80	90	90
0.43	0	0	53	73	82	80
0.45	0	0	62	68	74	60
0.47	0	0	68	54	59	65
0.49	0	0	70	27	18	54
0.51	0	2	64	10	5	38
0.53	0	8	48	2	1	22
0.55	0	18	30	2	0.5	23
0.57	0	29	16	1	0.5	26
0.59	0	42	6	0	0	11
0.61	0	50	3	0	0	12
0.63	47	54	1	0	0	11.5
0.65	74	57	0	0	0	10.5
0.67	78	57	0	0	0.2	23
0.69	75	55	0	1	12	51
0.71	74	52	0	2	52	79

This table shews that :

— the red lights give a light containing no yellow sodium rays : their spectrum is entirely in the red and orange band;

— the green lights have a slightly blue tint : their spectrum contains most of the

(1) This limit corresponds to the angle at which the intensity of the beam of light is only half that along the axis.

(2) The coloured glasses used on the semaphores have to comply which the same specifications.

green and blue waves with a little yellow;

— the orange lights give a spectrum containing all the yellow, most of the red, a little green, but no blue at all;

— the spectrum of the purple lights contains most of the blue and green, and a narrow band of the extreme red;

— the spectrum of the « moonlight » white contains almost all the blue and green, about 10 % of the yellow and of the orange and a rather high proportion of the red. Seen in daylight, these lights appear slightly blue, and a yellow kerosene flame placed behind a « moonlight white » glass appears perfectly white.

The transmission power of the coloured lenses and glasses is on an average only 20 % for a red lens and from 40 to 50 % for a yellow lens. A fairly large tolerance is allowed on this point.

The *panels of the daylight signals* are composed of three light units respectively red, orange and green. The « G. R. S. » panels are of three different types.

— The types « D » and « E » (figs. 34 and 35) in which the three lamp units are arranged on a vertical or horizontal straight line : each lamp is fitted in a cast-iron box (fig. 36) with a separate visor, the parallelism of the three optical axes being assured at the Works by very carefully machining the bolting up faces of the boxes.

— The type « G » (fig. 37) characterised by the triangular arrangement of the lamp units is very compact, the three lights being contained in a single rectangular box and protected by a single hood.

In order that a panel may be exactly set as to direction which must be done with extreme precision in view of the very small spread of the luminous beams, the « G. R. S. » fits its panels with a slot and adjustable support (fig. 38). The direction is roughly set during erection of the signal : the exact setting is done by means of the adjustable support which allows the panel a movement of 5° in the vertical plane (screw V) and 10° in a horizontal plane (slotted sector C).

To meet the possibility of lamps going out, the American builders have designed various arrangements :

— use of a spare lamp in each lamp unit;

— use of a double filament lamp : the generally adopted method; when the main filament fails, the second filament still gives an indication during a more or less lengthy period;

— the use of a special fitting using additional relays which automatically replaces every burnt out lamp by a light which gives an equally safe indication.

In practice the present tendency of the American systems is to limit the number of hours of burning of the daylight signal lamps to a certain figure much below the number of hours guaranteed : 1 000 hours, for example, for a guaranteed life of 2 000 hours. This method is completely satisfactory.

We must mention a most ingenious type of signal which only uses one luminous source to give three indications : red, orange and green. This signal known as the « *Searchlight* » was designed and made by the old « Hall » Company for the New York Central System : it consists of (fig. 39) a lamp placed before a reflector R which gives a reflection of the filament at I, the focal centre of the stepped lens L made of clear glass. A moveable frame E, on which are fastened three small coloured glasses R, J and V (respectively red, orange and green) moves about I : this frame is worked directly by the moving part of a three position relay. At each of the positions of the relay, one of the three glasses comes to I, which enables the three desired indications according to the position of the track circuit, to be shewn. The use of the reflector im-

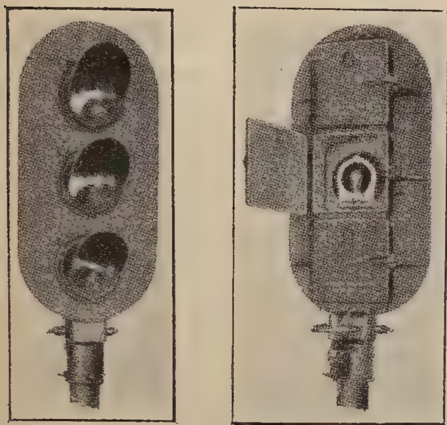


Fig. 34.

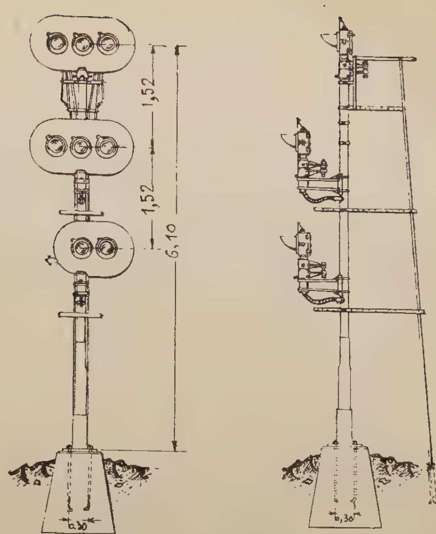


Fig. 35.

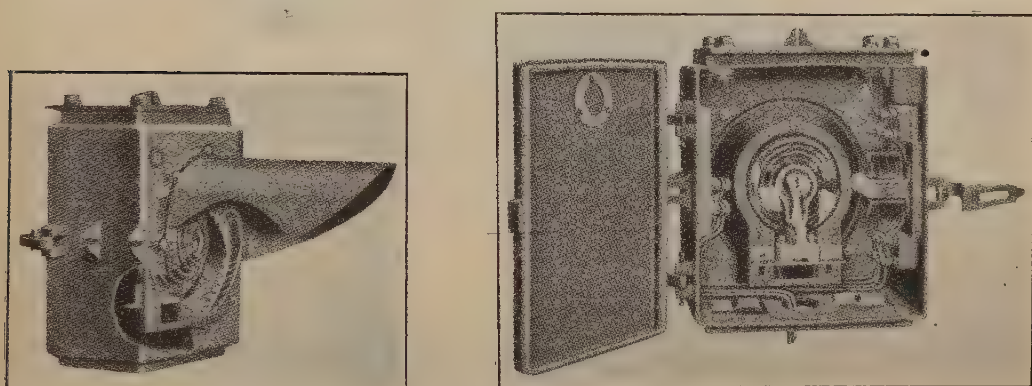


Fig. 36.

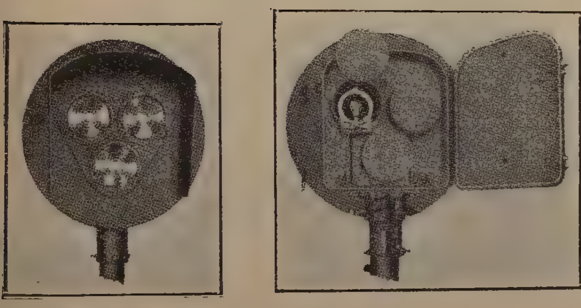


Fig. 37.

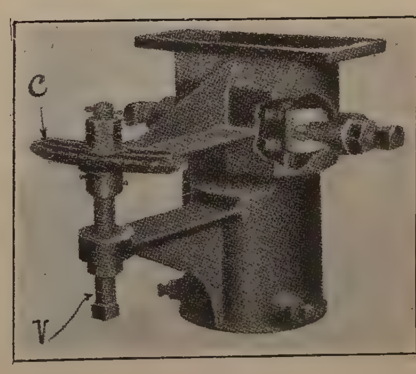


Fig. 38.

Figs. 34 to 38.

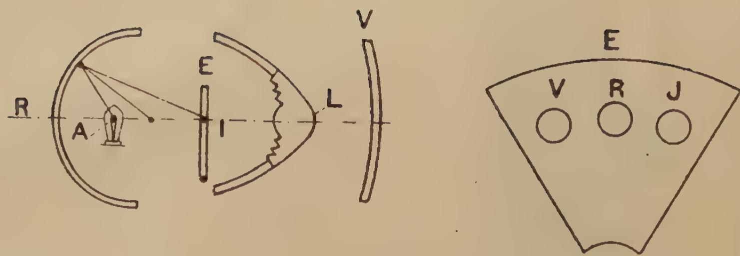


Fig. 39.

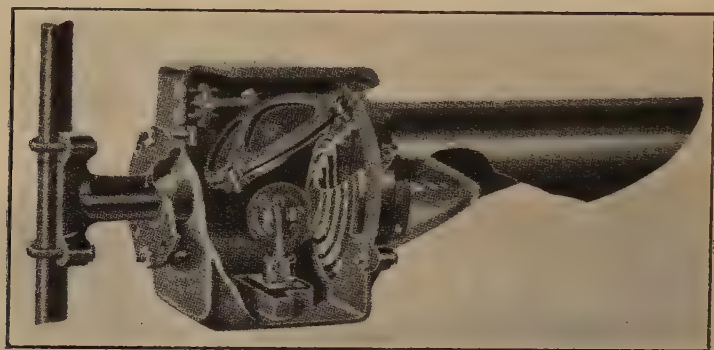


Fig. 41.

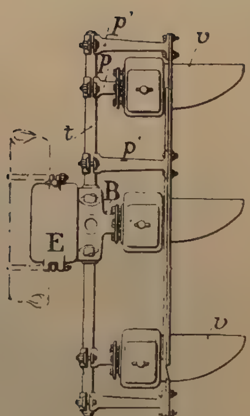


Fig. 43.

Fig 44.

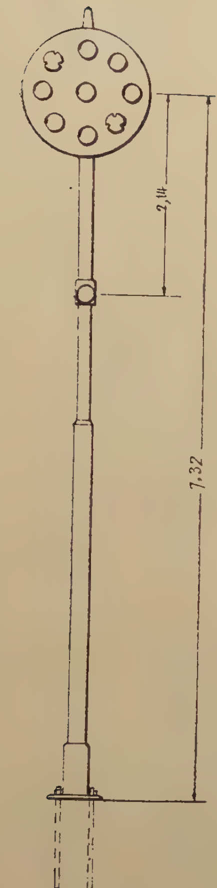


Fig. 40.

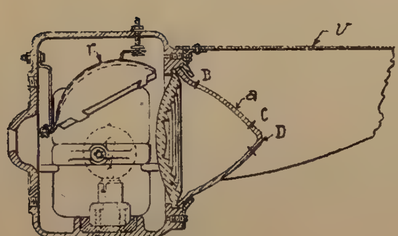


Fig. 42.

proves the efficiency of the optical system and makes it unnecessary to use a lamp with compact filament : this signal is consequently fitted with an ordinary automobile headlight bulb. It is to be noted that the presence of this reflector does not give rise to phantom indications, because all luminous rays from outside sources reflected by it pass through the coloured glass placed at I and thereby give the proper colour indication.

Position daylight signals. — The daylight position signals (fig. 40) were invented by Mr. Rudd, the Chief Signalling Engineer of the Pennsylvania System.

The back of the panels is made up of a circular iron plate mounted on a post or signal bridge with three sets of holes drilled in it (one horizontal, one vertical and the third at 45° with the horizontal). In each opening a lamp unit is fitted, consisting of a plain lens, at the focal centre of which is a lamp with compact filament. The lenses not being coloured, have a very high transmission value; it only requires a relatively low power to get a luminous beam of great intensity. This signal can give a fourth indication by adding a luminous line of lamps inclined at 45° symmetrically in regard to the ordinary position. No special arrangement is required to meet the case of a lamp going out; as if one lamp of a line should burn out there remain two which are sufficient to give a positive indication.

Figures 41 and 42 illustrate a *lamp unit* for a position signal manufactured by the « Union Swith & Signal C°. ». An exterior stepped lens of 135 mm. (5 5/16 inch-) diameter (« inverted type ») is protected by a glass *a* of special shape and composition called « cover glass ». This glass gives a slightly yellow tint to the light transmitted which makes it easier to distinguish whilst giving it high penetration in fog. The bulb with compact filament is placed at the focal centre of the lens. A mirror reflector *r* is arranged above so as to direct groundwards some light rays to

give a good visual indication near the signal. The setting of the lamp carriers and the centering of the filaments in relation to the bulb caps is done very carefully at the works. The usual consumption of lamps of position signals of the « U. S. S. » is 7 1/2 watts at 12 volts; in service they are run slightly undervolted (11 to 11 1/2 volts) which gives them a longer life and reduces their consumption to 6.3 to 6.9 watts. The danger of phantom indications is greatly reduced by the form of the protector glass *a* : on the one hand the rays reflected on the zone B C are not thrown back towards the locomotive, and on the other hand, the end D of this glass is frosted which prevents any reflection on the corresponding part. In addition, the lenses used are painted black on the cylindrical part of the steps, a method which also helps in eliminating all possibility of phantom indication.

As with the colour signals, a hood V of sheet iron 270 mm. (10 5/8 inches) long, to protect each lamp unit from sunlight rays, extends round more than half the perimeter of the lens, and reduces to a minimum the chances of an accumulation of snow or of ice on the protector glass *a*.

The different boxes carrying the lamp units are held by three tubular spindles *t* fastened to a cast iron box B at the centre of the signal (fig. 43).

The complete panel (fig. 44) is fitted up at the works where the delicate lining up of the optical axes of the seven lamp units, which have to be exactly parallel is done : it is delivered ready to be fastened to the signal post, the various lamp units being connected to the terminal box E by insulated wires. As to the current supply wires, they are taken by a flexible tube from the interior of the signal post to this terminal box so that the alignment of the signal can be altered without danger of damaging the cables.

Working of the daylight signals. — The supply circuits of the daylight signals are extremely simple : ordinary conductor wires connect the different lamps of a position signal or the different lines of a position signal, either to the single transformer of the signal, or to the three individual transformers of each unit or of each set.

It would seem that the present tendency in the United States is to use individual transformers for the lamps of colour signals supplied by alternating current. The contacts of the track relays are inserted in the primary circuits of these transformers instead of on their secondaries; under these conditions the intensity of current passing by the contacts is considerably reduced. In addition, this arrangement allows the tension to be adjusted with much greater exactitude.

We will not deal too fully with the schemes for equipping the block with daylight signals, for which many variants are possible (colour signals, or position signals, or alternating continuous current block with two position track relays and line relays, or with three position relays). One of the most frequently used constructions is that described by Mr. Balling in his article in the *Revue Générale* of November 1920 (Appendix 2, Alternating current automatic block with daylight signals on double track line).

We will limit ourselves to pointing out the need occasionally felt for a special type of relay called « slow action relay » in which on de-energising the top contacts only open after a certain time interval. The « G. R. S. » for example, supplies a delayed action continuous current relay, the contacts of which open 8/10 of a second after the electro magnets are de-energised. This result is obtained by inserting a copper sleeve between the winding of each electro magnet and its soft iron core. The same retarded action is obtained with alternat-

ing current relays by inserting a gear in the transmission of the movement to the contact fingers. In the case of two-element alternating current relays, all that is needed to make the relay slowed in action is to make the local element more powerful.

These delay action relays are used in conjunction with three position track relays. They prevent a fugitive red indication being given at a given signal when changing from caution to line clear : at the same time they hinder the propagation of fugitive yellow and red indication waves affecting all signals ahead.

Wherever commercial supplies of current at low cost are available, the signals remain permanently alight; but when recourse has to be made to primary cells or accumulators, it may be necessary to limit the time the lamps are alight to a short time before a train reaches the signal. With this object the Americans use two main types of fitting for « *approach lighting* ».

The first type (used for example on the New York, New Haven and Hartford System), consists in replacing, at each signal site, the auxiliary resistance in series with the track battery by a relay of equal resistance. This relay is energised on a train approaching, when the intensity of current supplied by a shunt on the preceding track circuit exceeds the excitation value. Its upper contact then closes the supply circuit of the light controlled on the panel. This method has one drawback : if a rail joint bond break or has too high a resistance, the lamp does not light up until the joint is passed and thereby there is some risk of its indication being given rather late.

The second method, used on the Pennsylvania System, uses a line relay having its contacts in the supply circuits of the lamps of a panel. This relay being controlled by the lower contacts of a preceding track relay, the lamps of a panel only light up when a train has entered the section corresponding to this track relay.

Comparison between the different types of signals. — Most American Signalling Engineers *prefer daylight signals to the automatic semaphore signals* for the following reasons :

— the elimination of all mechanical parts lessens the chances of failures by seizing, binding, freezing up, etc.;

— their average visibility is better;

— the indication given is the same both by day and by night;

— in addition they take up less room; their first cost and upkeep cost are less.

As regards daylight signals, colour signals have to their credit some advantages over the position signals :

— a colour signal panel uses actually 18 watts at most, whereas a position signal panel uses at least 21 watts (7 watts for each of the three lamp units of a line);

— the number of lamps to be renewed is less with the colour signals than with the position signals;

— setting the different lamps of a panel to the correct direction is much more easily done with colours signals.

The position daylight signals certainly enable four very clear indications to be obtained without difficulty when using a single panel, whereas colour daylight signals require for the same results to be given by the indication of a single light the use of a purple, blue, or moonlight white light, which at a distance may have insufficient visibility. The indications of the position signals are not likely to be wrongly taken by a driver suffering from colour blindness. Finally, if one lamp out of a line of three go out, the signal continues to give a quite clear indication.

It is none the less the case that most of the American railways definitely pre-

fer the colour signals to the position signals.

On the one hand, their visibility appears to be greater : on the other, their psychological effect on the driver is greater, the colour of a light causing him to react much more quickly than the position of a line of lights. Finally, in times of fog the position daylight signals seen from a certain distance, owing to the diffusion of the light, appear like a bright blur, the orientation of which is difficult to appreciate. This fact is the more marked as the power of the lamps is increased to give greater carry to the lights.

III. — Production and distribution of energy.

General. — Classification of the supply systems. — The supply systems used in the United States for working the automatic block can be divided into two groups :

1. Systems using entirely local supplies of continuous current (primary cells or accumulators);
2. Systems in which the energy is supplied from mains carrying industrial current.

In this second group the three following systems are included :

— the « *alternating current straight* » system in which all the circuits use alternating current;

— the « *alternating current floating* » generally utilising : for the track and line circuits, and for working and lighting the signals, continuous current supplied by rectifier accumulator groups using industrial alternating current; for lighting of the daylight signals, industrial current, and, should this fail, continuous current from accumulators;

— the « *alternating current primary* » system similar to the preceding, but using as the supply of continuous current batteries of primary cells instead of rectifiers and accumulators. This last system being unlikely to have any greater future before it, will not be described in this article.

Local supply by primary cells. — The American companies tend more and more to give up the use of sulphate of copper cells which give an electromotive force which varies with the temperature and are excessively expensive in labour and upkeep.

On the other hand, the use of caustic soda cells is becoming general. These cells (Waterbury, Edison, etc.) are based on the Lalande : the electrolyte is a concentrated solution of caustic soda, the positive electrode is in zinc and the negative copper oxide. The capacity of these cells is practically constant and enables many varying outputs to be obtained. Their internal resistance being very low (of the order of 0.02 ohm) they are only used in track circuits when protected by an additional resistance in series. The standard capacity of soda cells used in the United States is 500 ampere hours : the discharge rate of such cells should not exceed two amperes, and under such conditions renewal is only necessary every eight or nine months.

The electromotive force of soda cells is about 0.65 volt. The number and grouping depend upon the work to be done : 2 to 5 cells in parallel for supplying track circuits, 12 to 16 in series for working the semaphores, and 10 to 16 in series for illuminating the daylight signals.

Supply by the « alternating current straight » system. — In this system the alternating current is supplied at high tension to the sub-stations feeding a distribution main running alongside the track. At each signal there is a transformer reducing the voltage down to 110; from the secondary of this transformer the current is taken to other transformers

which give the different voltages needed for the track circuits, signals, local windings of the two element relays, etc.

We will limit ourselves to giving some details of this type of installation, already in use in France, taken from American practice.

The dominating pre-occupation in straight alternating current installations is to overcome any risk of a current failure which might affect the working of a complete section of line.

The American systems have endeavoured, first of all, to get the greatest reliability in the supply of the current itself by careful selection of the power stations, by watching over the independence of the sub-stations, by close spacing of the sub-stations to limit the length of line supplied by each, and finally by always making provision for stand-by supplies. In particular, the use of automatic stand-by sub-stations is increasing more and more. These sub-stations are not as a rule working; they automatically come into action when the tension in the feeders falls more than about 15 %; the normal supply is then disconnected and replaced by the reserve supply. Contrariwise, when the normal supply can be restored, the stand-by sub-station is disconnected either by hand or automatically.

The American systems have also endeavoured to safeguard themselves as much as possible against breakdowns in the distributing mains. A certain number have on this account laid in two separate mains; at each signal site special change-over relays cause the current supply to the signals to be transferred automatically from one main to the other when the necessary tension is too low in the normal supply main.

The use of overhead lines is nearly always preferred to that of cables with which there have been many failures through excessive tension on some of the companies lines. Overhead lines have also the great advantage of enabling a defect to be easily located.

The tensions adopted for the distribution mains in the « straight alternating current » system vary from 1 000 to 6 000 volts according to the length of the sections and the strength of the currents. The general frequency allowed is 60 periods. Monophase distribution is generally preferred to three-phase, but this entails certain complications in the fittings.

Supply by « alternating current-accumulators ». — This method of supply, which has not yet been used in France, is particularly interesting.

The « straight alternating current » system has to be used on electrified lines; on the other hand, on steam lines, the continuous current track circuit can be used, and as we have seen has many supporters in the United States.

Some American signalling engineers are also of the opinion that a serious breakdown is always possible with the « straight alternating current » system, whatever stand-by arrangements are adopted. These engineers prefer the lay-out which gives, at least as reserve, a local and individual supply to the signals such as the « alternating current-accumulator » system provides.

The method of supply, most often applied to daylight signals, consists essentially of :

— commercial supplies of alternating current;

— transmission line for this alternating current;

— and at each signal site :

— a step down transformer;

— two « rectifier-accumulator » groups in which the accumulators act as buffers.

The track and line circuits, the control circuits of the signals and the lights of signals lighted electrically are supplied

with continuous current by the two rectifier-accumulator groups.

The signal lighting circuits are normally fed by the transformer : if the alternating current fail, the circuits are fed by the line circuit accumulator battery, the change-over being made by a special relay.

One of the main advantages of the « alternating current-accumulators » system is that it enables a commercial current of a low kilowatt-hour value to be used having no special guarantees as to constancy and to regularity. The buffer batteries provide at each signal a reserve supply of energy which can assure over a fairly long period the working of all the circuits at the same time.

The commercial current being available at as many places as can be desired, the distribution lines are of short length, at low tension (400 volts) and their first cost is considerably reduced.

The characteristic feature of the « alternating current-accumulator » system is the rectifier-accumulator group shewn in figure 45. A transformer T steps down the alternating current to the desired value. Its secondary supplies the rectifier R. The accumulator battery is shunted off at BB'. The signal circuit supplied by the group is connected at CC'. Normally the current supplied by the rectifier is used on the one hand to charge the battery, and, on the other, to feed the branch circuit CC'. The difference of potential between B and B', which in the absence of a buffer battery would be represented by the curve 2 (fig. 46), varies simply, following curve 3, between narrow limits (between 2 and 2.2 volts for a single cell). If the current to the transformer primary fail, the battery supplies CC', the rectifier R preventing any discharge through the transformer secondary in the direction B R S B'.

The rectifier should supply a current of sufficient strength to meet the consumption of the branch circuit CC' and to make up any losses from the battery which should be kept constantly fully charged.

Naturally, if the supply of alternating current is only available for twelve hours daily, for example, the output of the rectifier ought to be increased in order to give the same total quantity of energy to the battery and to the signal circuits.

The only rectifiers available for the first « alternating current-accumulator » installations were the mercury vapour or the mechanical vibrator types : The first could not be adapted technically or economically to the « alternating current-accumulator » system. The vibrator type therefore was the only one used for many years. It has now been supplanted by the electrolytic rectifiers, the standard type of which is the « Balkite » (fig. 47), consisting of two metallic electrodes, one of lead and one of tantalum immersed in sulphuric acid. The tantalum electrode only passes a half wave of the alternating current and gives a current of constant polarity, perfectly suitable for charging accumulators.

The Balkite rectifier has a practically

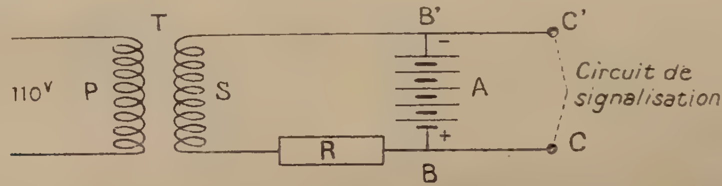
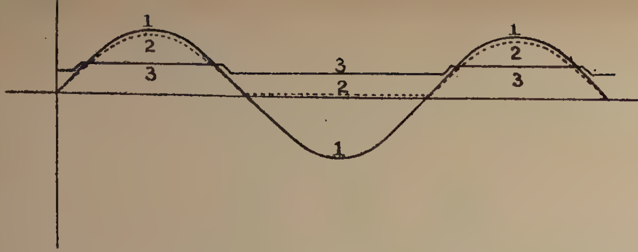


Fig. 45.

Explanation of French terms: Circuit de signalisation = Signalling circuit.



1 – Courbe représentant la tension secondaire sans redresseur.
2 – Courbe représentant la tension du courant "redressé sans batterie tampon".
3 – Courbe représentant la tension du courant "redressé avec batterie tampon".

Fig. 46.

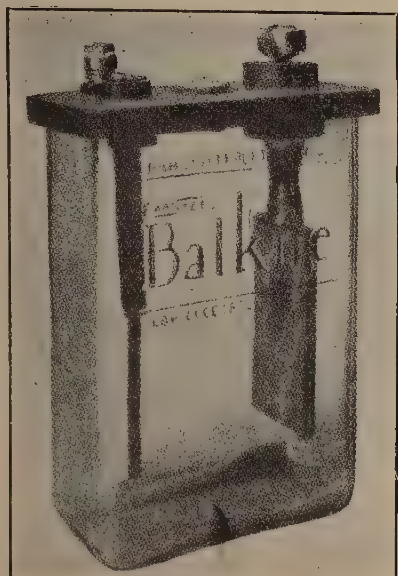


Fig. 47.

1. Courbe représentant la tension secondaire, etc. = 1. Curve shewing the secondary voltage without rectifier. — 2. Courbe représentant la tension du courant « redressé sans batterie tampon » = Curve shewing the tension of the current « rectified without buffer battery ». — 3. Courbe représentant la tension du courant « redressé avec batterie tampon » = 3. Curve shewing the tension of the current « rectified with buffer battery ». — Rendement en % = Per cent efficiency. — Taux de charge, en ampères = Charging rate in amperes. — 1 élément = 1 cell. — 5 éléments = 5 cells.

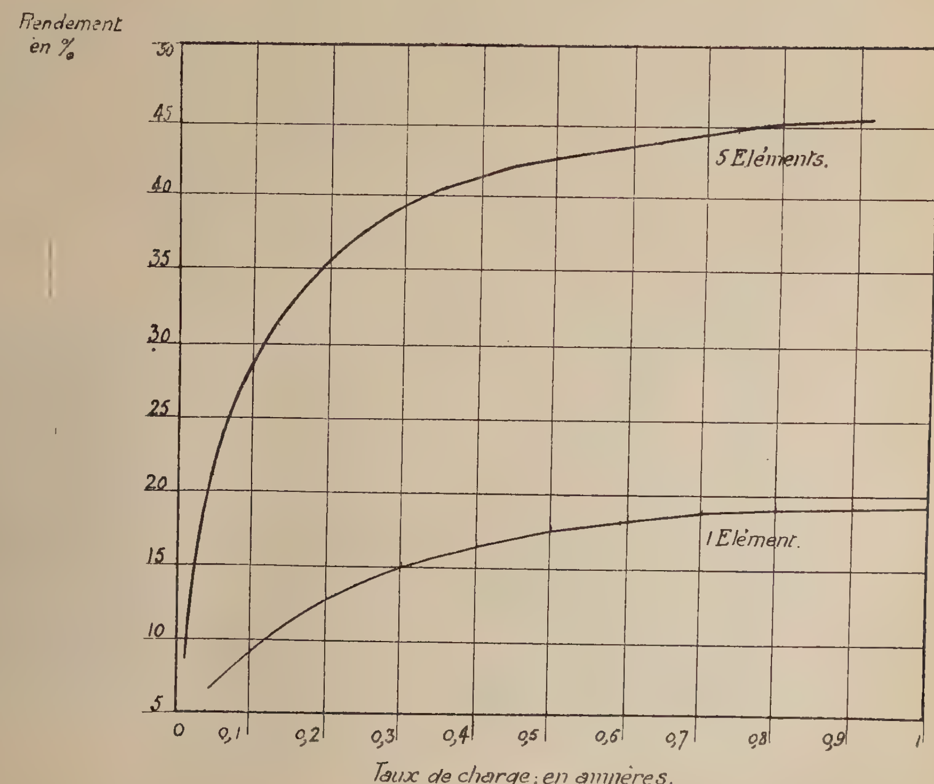


Fig. 48.

constant potential characteristic : thanks to this, the charging current increases as soon as the voltage of the battery begins to fall.

A Balkite rectifier can charge as many as four accumulator cells in series at three amperes or six cells in series at one ampere. If batteries of higher electromotive force are to be charged, they should be divided into several groups, each connected to a Balkite unit. If the intensity of the charging current is to be increased, a number of rectifiers can be connected in parallel. Figure 48 gives the output of a Balkite rectifier (transformer and rectifier in one unit).

The whole of the American Companies agree upon the complete reliability of the Balkite rectifier. It works satisfactorily between — 13° F. up to the boiling point of the electrolyte. Frost does not seriously affect it : if a frozen rectifier is put under tension, the heat given up quickly melts the electrolyte and the rectifying action commences at once.

Amongst the many advantages of the electrolytic rectifier can be cited its practically unlimited life and the small upkeep required. It is only necessary to add pure water to replace evaporation, and this is only needed at long intervals owing to the large capacity of the element (fig. 49, maximum length of working without adding water). Furthermore, if the level of the electrolytic fall below the bottom of the electrodes the rectifier would not be damaged in any way : it would simply cease to act, but would again give its normal output as soon as water was added.

The electrolytic rectifier, as opposed to the vibrator rectifier, does not give rise to any undesirable hum by induction in the neighbouring telephone circuits.

The Balkite rectifiers are used with a special transformer, fitted on their secondary winding with a number of terminals to give a selection of tensions from 0.25 volt to 25.5 volts in steps of 0.25 volt. This arrangement, in conjunction with a variable resistance, makes it possible to adjust the charging current very accurately. The transformer shewn in figure 50 is a special type with two secondaries (« duplex » type) : it can charge at a time either two track batteries, or two signal batteries, or a track battery and a signal battery.

The working conditions of the battery in the « alternating current-accumulator » system are good, as it is maintained constantly charged by a low charging current. Thanks to the smallness of this current there is practically no gas given off nor heat generated. The evaporation is in consequence reduced, and there is no need to add water to the cells more than two or three times a year.

On the other hand, the battery being always fully charged, all danger of freezing is avoided as the electrolyte retains a specific gravity at which it will not freeze even during the severest winter.

It is necessary to make sure that the battery always receives a sufficiently high current to maintain it fully charged : it is also desirable that this current should not exceed certain limits. Two methods are available for taking care of this : by testing the specific gravity of the electrolyte and the second by means of a voltmeter. Te second is the better : all that is needed is to test the voltage at the battery terminals with the rectifier connected up.

Experience in the United States has shewn that very satisfactory results are obtained it the average tension applied varies between 2.1 volts and 2.2 volts per cell. The American railways generally use the figure of 2.15 volts as the value of the tension to be maintained as constantly as possible at the accumulator terminals (rectifier working) : slight variations on either side of this average

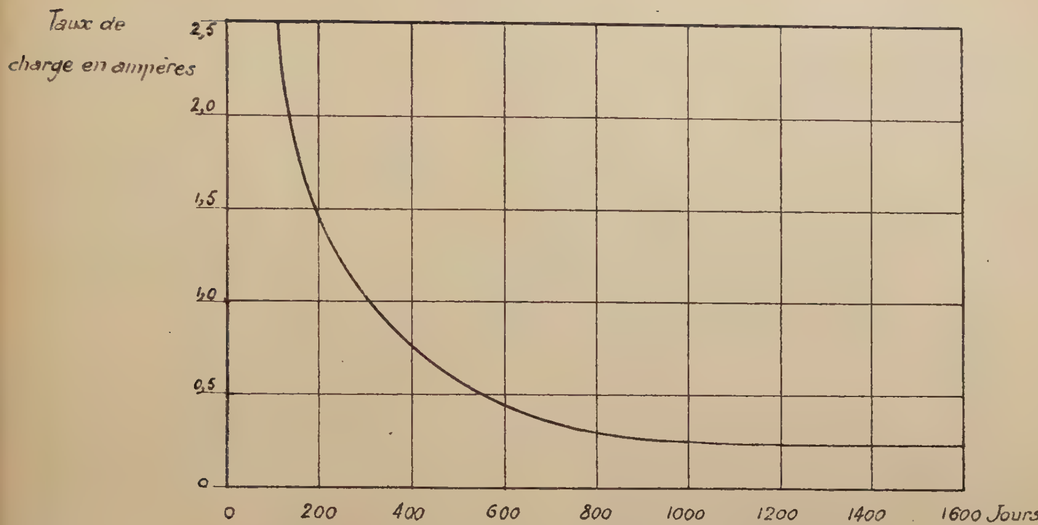


Fig. 49.

Explanation of French terms : Jours = Days — Taux de charge en ampères = Charging rate in amperes.

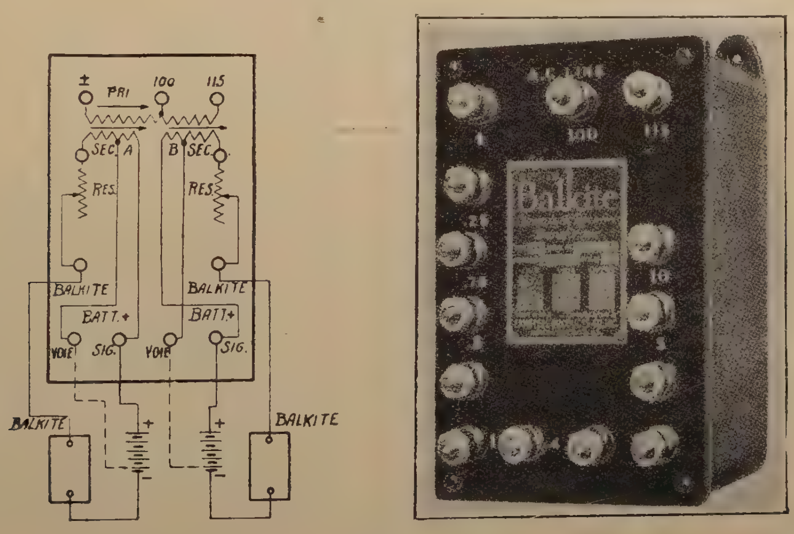


Fig 50.

are allowed if the tension remains within the limits 2.1 and 2.2 volts. An exact regulation of the intensity of the charging current is not obtained but great precision is not needed. The intensity of the charge ought to be enough to make good the losses of cells run down to a very low value : the accumulator

will stand perfectly well a much higher charging rate than this minimum value.

In the United States it is recommended the batteries be given sufficient capacity to supply all current between two regular inspections with a fairly high margin in addition. If the average consumption is 6 ampere hours a day and the batteries are inspected once a week, the battery should supply 42 ampere-hours should an interruption in the supply current occur immediately after an inspection, and is not discovered until the next one : it is reckoned in the United States that in such a case a capacity of 75 ampere-hours gives an ample margin of safety. The necessity for reducing as much as possible the variation in voltage at the track circuit terminals when the rectifier ceases to feed the installation also makes such a capacity needed.

We will only give here a simplified diagram shewing how the various details described above are assembled at a coloured daylight signal (fig. 51). In this sketch the feed current (440 volts, for example) is taken direct to a Balkite transformer with two secondaries. The first secondary S of the transformer supplies an alternating current of 8 volts to the rectifier B, which maintains a potential difference of 2.15 volts at the terminals of the track battery *s*. The second secondary S′ supplies an alternating current of 20 volts to the rectifier B′, which maintains a potential difference of 8.6 volts at the terminals of the 4 cells in series making up the line battery *s*′.

Finally, a special transformer T_1 normally supplies 8 volts current to the lamps of the coloured daylight signals each of which consumes 18 watts. Should the current fail, the relay R, branched off the secondary of this transformer, becomes de-energised : its lower contacts *p* and *p*′ close and assure the supply of current to the lamps from the line battery *s*′.

The robust and simple exterior appearance of the rectifiers and accumulators should be noted : they are compact in form and of small size. No gassing is to be feared, nor any discharge of the acid in view of the low charging rate. These details can consequently be placed in the same building as that in which the track line relays are housed. Figure 52 shews one of these shelters, the simple arrangement of which will be noted.

Tendency of American railway practice. — It can be taken that three systems are favoured by the American railway companies : the automatic block with primary cells with separate supply to each signal, the block using « alternating current-accumulators » and the block using « straight alternating current ». The last method is chiefly in use on lines with electric traction. The first tends more and more to give place to the second which has the advantage of giving at each signal site an independent reserve of energy *always fully charged*, and always ready to feed the circuits during any failure of the normal supply of current. As a matter of information, of the installations put down during 1926, 25 % were « primary cells », the same percent with the « straight alternating current » system and 50 % the « alternating current-accumulator » system.

The system of « approach lighting » described previously has the advantage of considerably reducing the consumption. It makes it possible to light the signals by primary cells, and for this reason would appear likely to have some future before it.

IV. — Signalling Department organisation on an American railway system.

The American companies have usually a separate department dealing specially

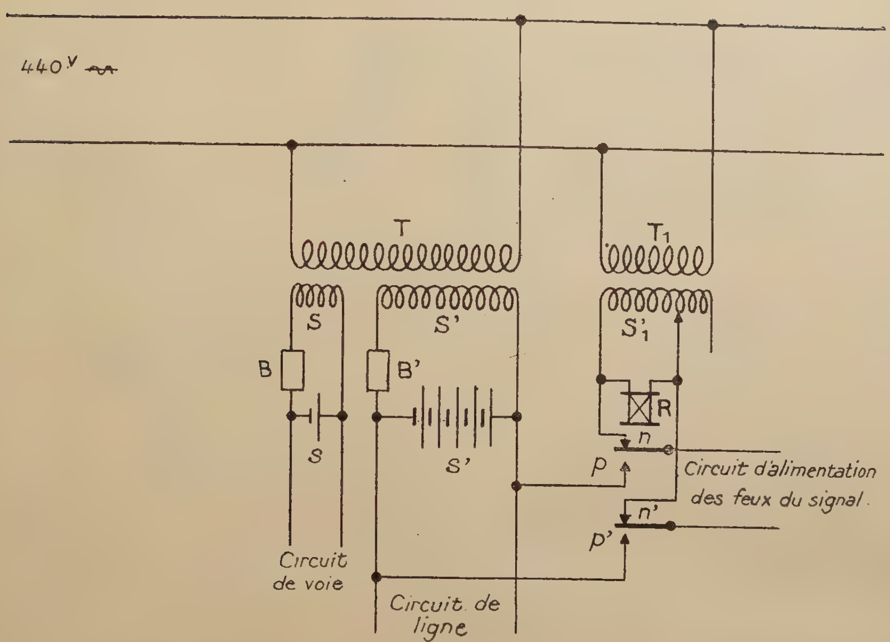


Fig. 51.

Explanation of French terms : Circuit d'alimentation des feux du signal = Supply circuit for signal lamps. Circuit de ligne = Line circuit. ~~Circuit~~ Circuit de voie = Track circuit.

Fig. 52.

with signalling and in particular with the automatic block. This Department under a *signal engineer* or *chief signalling engineer* or *superintendent of signals* has five main sections : construction, upkeep, inspection, designing and drawing offices, and accountancy.

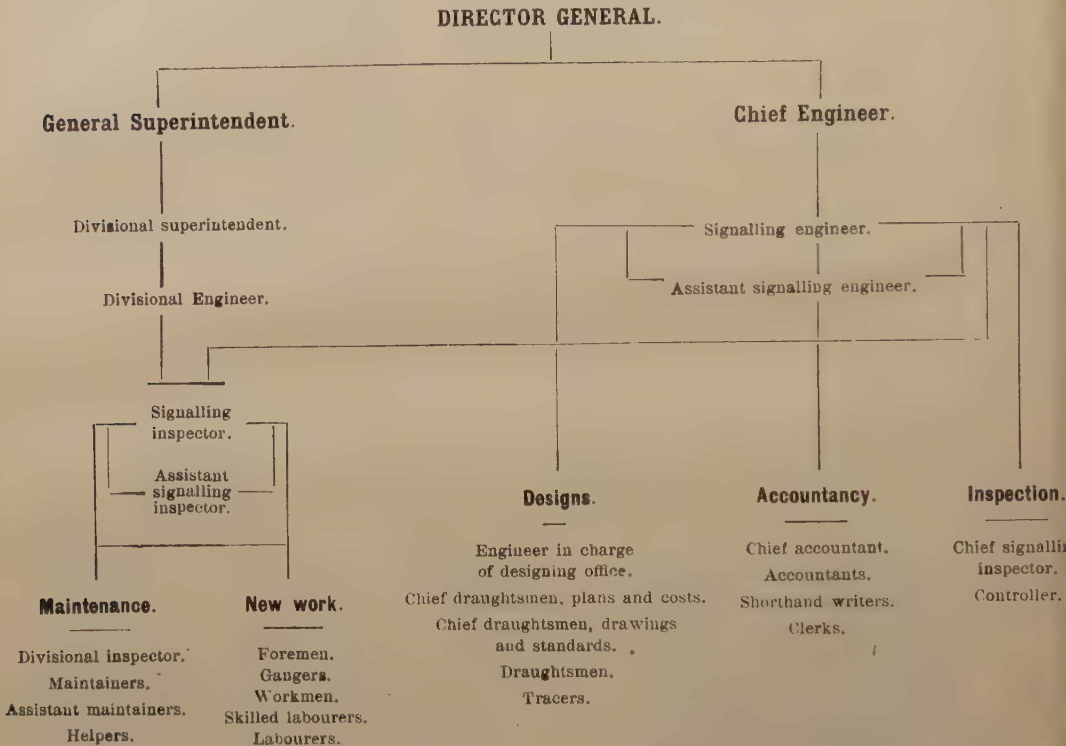
The general organisation on the large American systems is with hardly an exception based on the « divisional » system, much more decentralised than the departmental system of the French organisation.

In the divisional system the railway is divided into regional areas, called « divisions », having considerable independence : each division has at its head a « superintendent or « area director » having authority over the whole services throughout the division. The area

directors are under the orders of the *general superintendent* who is one of the assistants of the director general or « vice president ».

The headquarters services (rolling stock, motive power, permanent way, signalling, etc.) have a general technical role : they are controlled by their respective engineers under the direct authority of another assistant of the director general, known as the « chief engineer » who deals with all technical questions.

In this form, the signalling department takes its place as shewn in the following diagram :



The divisional inspectors known as « supervisors » look after the whole « division » : they report directly on all questions of upkeep and working of the signals to the divisional superintendent, who in turn receives all necessary technical instructions from the signalling engineer. In addition, the supervisors refer direct to the assistant signalling engineer on certain technical questions, for particular instructions on questions and on matters not dealt with by the specifications or outside agreed practice.

The establishment of *upkeep staff* under a divisional inspector consists of *maintainers, assistant maintainers,* and *helpers.* Each maintainer is responsible for the whole upkeep of a section : he is responsible for the working of the automatic block and for that of the interlocked signal boxes.

So that the maintainers can get over

their sections quickly, the railway companies supply petrol motor driven trucks. These trucks driven by a 3 to 4-H. P. motor are very light (about 440 lb.) and are fitted with levers by means of which one man can derail them. They can carry two men and repair material.

The maintenance men are provided with a complete outfit of standard tools with which they can carry out all repairs and replacements for which they are responsible. Small buildings are also provided, each of two rooms, one for office and store for small details, and the other for workshop store for heavy stores, and garage for the truck.

GENERAL FEATURES OF THE AUTOMATIC BLOCK IN THE UNITED STATES.

Profiting by the experience acquired during many years of research and from the extremely extensive applications in use, the United States railways have perfected all the technical details of the automatic block. There was much hesitation and many discussions about 1911, but since that period the method of construction of the plant has become more fixed, theory has become established and automatic signalling has become definitely codified. The American engineers now consider that no apprehension need be felt as regards safe working provided the installation is in accordance with the « American Railway Association » specifications which are worked to by all reliable builders.

The American automatic block calls for certain remarks of a general character which it appeared interesting to briefly state hereafter.

Principles and characteristic features of the signalling. — The signalling in the United States is essentially *positive.* It actually gives the drivers in characteristic forms an assurance that they have an open line (semaphore arms — vertical and offset with regard to the post, green light for line clear) and do not content themselves by giving these indications by simply effacing a disc or arm.

They also tend, by using three indication signals and by grouping signals *to reduce the number of observations* to be made.

They give a *logical succession of indications* for slowing down or caution repeated at each signal up to the point of reduced speed or stop or up to the signal authorising speed to be regained.

The semaphore or daylight signals used when applying these principles have also very good *visibility.*

On the other hand, certain details of American signalling appear open to discussion. Such is the case in which a number of signals are carried on one post, the line clear or caution indication is placed against the stop indications which the driver has not observed. As an example, the indication to pass at speed on to a branch is given by a green and two red lights. This way of doing it is far from the principles used in French signalling which requires a driver approaching a group of signals to obey the most restrictive signal indication. It would also appear to prevent full value being got out of the daylight signals which ought, as a rule, to give one single indication, the most imperative, and not a group of indications.

Technical features of the design as carried out — The care taken to ensure proper working of the installations has been pushed very far in the United States. By laboratory experiments, tests on the ground, constant collaboration with the railway companies, the makers have succeeded in getting out equipment which rightly inspires the greatest confidence.

It should be noted that one of the main preoccupations of the manufacturers and of the railways has been to provide simple and easily fitted parts. Experience has shewn them that in use complications of any kind inevitably result in failure which, by interfering with train movement, is prejudicial to safe working. The American engineers say « Keep the trains moving » by which they understand a balancing of the hypothetical advantages obtained by the functioning in an exceptional manner of certain safety devices and the too frequent stopping of trains which result when they fail to act.

The suppression of « overlaps », the independence of successive insulated sections, the normal position at line clear make the electrical equipment much simpler : the use of semaphores with the motor fitted direct on the signal arm shaft reduces the mechanism to its greatest simplicity.

Maintenance of the plant. — It should be pointed out that the upkeep methods for the automatic block have been very carefully developed in the United States. Supervision, repairs and renewal of parts are done very methodically, and a logically ordered staff makes it possible to consider at each stage improvements suggested by practical experience.

It will be noted that the American signalling departments endeavour to prevent the out doors staff from interfering with the adjustment of the delicate equipment which plays a leading part in securing safe working. The relays are consequently hermetically sealed and no alteration thereto can be effected out on the line; if defective, the apparatus is replaced and sent into the shops for attention.

MISCELLANEOUS INFORMATION

[621 .85 (.82)]

1. — White-metalling plant for the Central Argentine Railway.

Figs. 1 and 2, pp. 86 and 87.

(*The Railway Gazette.*)

The Monometer Manufacturing Co. (1918) Ltd., of Savoy House, 115-116, Strand, London, W. C. 2, has recently supplied to the Central Argentine Railway through the Consulting Engineers, Messrs. Livesey, Son & Henderson, one of their latest improved patented white-metalling and pressure die-casting installations. The plant includes interesting features. Figures 1 and 2 show it erected in the works, prior to despatch to South America.

The installation is intended to enable the various operations of melting-out the old metal from bearing brasses, etc., and of relining with new metal, to be conducted in series, avoiding multiple handling and the necessity of machining, at the same time economising space and facilitating manipulation generally. The first item is a de-metalling and a pre-heating plant, and a furnace for melting out old metal fitted with an inclined mechanical conveyor on which the items are placed, and by which they can be moved through the furnace as desired.

The furnace leads on to a metal table on which general operations are conducted before the items under treatment are placed in the tinning bath. From the latter they are transferred to one or other of two Monometer pressure die-casting machines, one designed for heavier and larger items and the other for smaller ones. In this particular installation the larger die-casting machine is in line with the working table and the furnace and the other at right angles. Another plant has the chain conveyor furnace at right angles to the working table and there is die-casting equipment at each end of the working table and a third machine attached at the side towards one end. Other general heating furnaces are also provided for the remelting and pre-heating of other special articles.

In the Central Argentine plant, kerosene is used as the heating agent for the conveyor furnace, the tinning bath and the pressure casting machine. All operations are conducted on the working table of the plant.

The pressure die-casting plants are of the standard Monometer patented and registered designs. The method of use for axlebox bearings and the like is as follows :

The heated bearings are first of all located on a special mandril over which the steel box fits, and this locates the bearings centrally in the box, where they are clamped by four small hand screws. The box with the bearing is then lifted up, swung over the die, and lowered into position, and the die is made so as to take up any variation in the length of the brass. The metal is then forced in under pressure and the box and finished bearing raised from the die and swung round through 180°. By further raising the box the ejector pins are brought into operation, forcing the finished bearing from the box, after which the box is swung round over a fresh bearing to be lined, and the operation repeated. The whole cycle of operation takes 2 3/4 minutes; bearings are produced dead to size, and relieved at the edges so as to avoid hand scraping. The smaller plant is designed on similar lines, but for use on a more general basis, such as tinned plugs for boiler tubes, locomotive slides and other

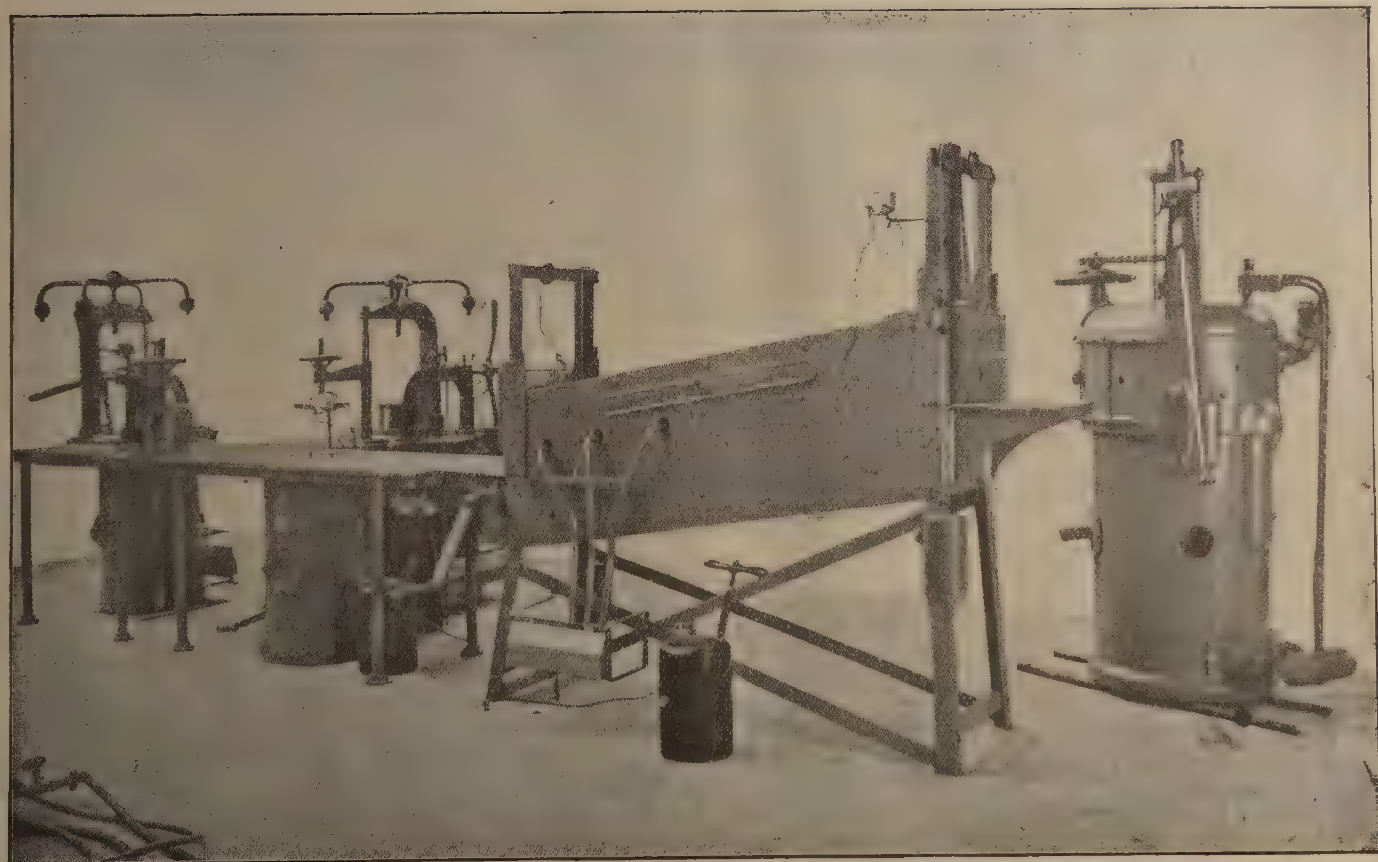


Fig. 1. — General view, showing furnaces, work table, and die-casting presses.

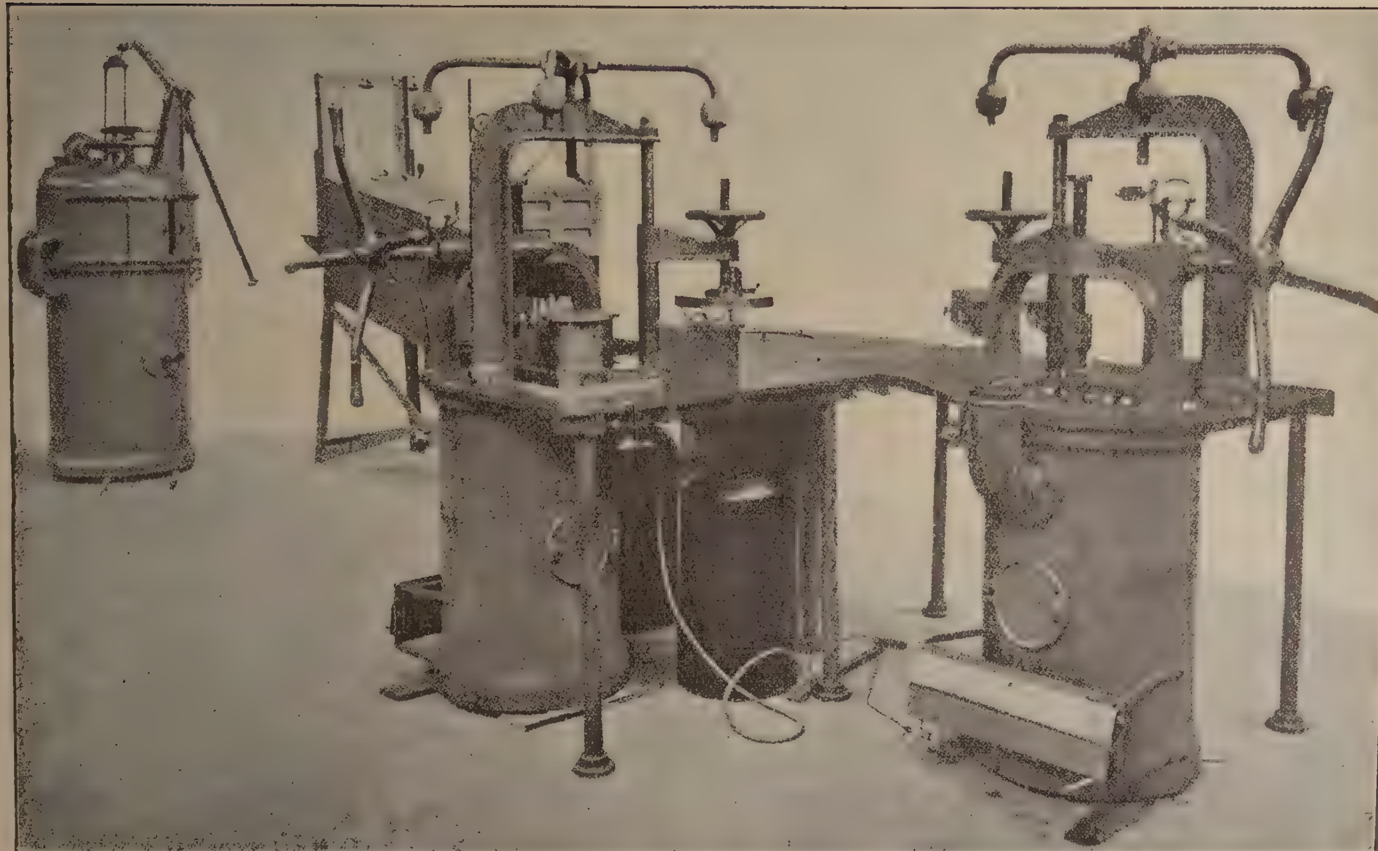


Fig. 2. — Another view of the plant ready for service.

miscellaneous rolling-stock, carriage work, etc.

So far no mention has been made of the saving in time over the old process which is effected by the Monometer system. As an example, it may be mentioned that to complete 25 to 30 R. C. H. axlebox bearings by the old pouring method takes approximately eight hours, whereas by the Monometer patent pressure system the same number of bearings can be completed in one to one and a half hours.

All Monometer productions are invented and designed by Mr. I. Hall, M. I. M. E., M. I. S. I., M. Inst. Met., member of the Société des Ingénieurs Civils de France, Chairman and Managing Director.

[388 .113 (.45)]

2. — Operating results of the Italian State Railways for the year 1925-1926.

(*Bulletin des transports internationaux par chemins de fer.*)

The following information for the above year has been extracted from the *Relazione dell' amministrazione delle ferrovie esercitate dallo Stato* (Report of the State Railways Administration), published each year by the General Direction of the Italian State Railways. Against these figures, for comparative purposes, have been given the figures for the years 1923-1924 and 1924-1925.

	1923-1924	1924-1925	1925-1926
Length constructed, end of year, in kilometres (in miles)	15 808 (9 823)	15 823 (9 832)	15 836 (9 840)
Length in operation, end of year, in kilometres (in miles)	15 745 (9 783.6)	15 760 (9 793)	15 771 (9 800)
Average length operated, in kilometres (in miles)	15 727 (9 772)	15 746 (9 784.1)	15 760 (9 793)
Rolling stock :			
Steam locomotives and rail cars, number	6 502	6 491	6 372
Electric locomotives and rail cars, number	509	572	584
per kilometre (per mile) of line in operation	0.445 (0.716) (1)	0.449 (0.723) (1)	0.421 (0.678) (1)
Passenger carriages, number	10 144	10 071	9 306
per kilometre (per mile) of line in operation	0.644 (1.036)	0.611 (0.983)	0.564 (0.908)
Brake vans and postal vehicles, number	4 514	4 468	4 158
per kilometre (per mile) of line in operation	0.287 (0.462)	0.270 (0.435)	0.252 (0.406)
Goods wagons, number	158 217	155 213	153 409
per kilometre (per mile) of line in operation	10.059 (16.188)	9.415 (15.152)	9.292 (14.954)
Length of journey of rolling stock :			
Passenger and mixed trains (in thousands of train-kilometres [of train-miles])	60 915 (37 852)	68 969 (42 856)	75 711 (47 045)
Goods trains (in thousands of train-kilometres [of train-miles])	51 065 (31 731)	58 044 (36 068)	60 830 (37 799)
Stores and service trains (in thousands of train-kilometres [of train-miles])	266 (165)	245 (152)	301 (187)

(1) Steam and electric locomotives and rail cars.

Length of journey of rolling stock (continued) :	1923-1924	1924-1925	1925-1926
Total (in thousands of train-kilometres [of train-miles])	112 246 (69 748)	127 258 (79 076)	136 900 (85 067)
Passenger carriages (in thousands of axle-kilometres [of axle-miles])	1 279 230 (794 891)	1 404 016 (872 431)	1 530 783 (951 201)
Brake vans (in thousands of axle-kilometres [of axle-miles])	256 688 (159 501)	282 895 (175 786)	305 117 (189 594)
Loaded goods wagons (in thousands of axle kilometres [of axle miles])	2 098 007 (1 303 665)	2 388 842 (1 484 384)	2 472 137 (1 536 142)
Empty goods wagons (in thousands of axle kilometres [of axle-miles])	611 525 (379 991)	707 113 (439 388)	775 648 (481 974)
Stock and service wagons (in thousands of axle kilometres [of axle-miles])	2 954 (1 836)	2 975 (1 849)	3 847 (2 390)
Post office vans (in thousands of axle-kilometres [of axle-miles])	117 556 (73 047)	129 859 (80 692)	137 284 (85 306)
Total (in thousands of axle-kilometres [of axle-miles])	4 365 960 (2 712 931)	4 915 701 (3 054 530)	5 224 817 (3 246 607)
Traffic :			
Passenger tickets sold (in thousands)	..	102 608	113 570
Goods carried on behalf of the public (in thousands of metric [English] tons)	... ...	57 058 (56 157)	58 606 (57 680)
Goods carried on behalf of the Railway (in thousands of metric [English] tons)	... ...	6 113 (6 016)	6 669 (6 564)
Total goods carried (in thousands of metric [English] tons)	... ...	63 171 (62 173)	65 275 (64 244)
Financial results :			
Passenger receipts (in thousands of lire)	1 194 894	1 415 707	1 639 100
1st class (in thousands of lire)	...	155 000 (1)	174 000 (1)
2nd class (in thousands of lire)	...	401 000 (1)	466 000 (1)
3rd class (in thousands of lire)	...	860 000 (1)	999 000 (1)
Receipts from luggage and dogs (in thousands of lire)	50 424	56 499	67 924
Receipts from goods (in thousands of lire)	2 034 005	2 608 558	3 158 516
Express (in thousands of lire)	392 110	509 948	580 329
Ordinary (slow train) (in thousands of lire)	1 641 895	2 098 610	2 578 187
Traffic receipts (in thousands of lire)	3 279 324	4 080 765	4 865 540
per kilometre (per mile) of line operated (in lire)	216 057.71 (347 704.90)	247 443.73 (398 214.89)	395 131.64 (635 891.24)
per train-kilometre (per train-mile) (in lire)	30.62 (49.28)	32.13 (51.71)	35.01 (56.34)
per axle-kilometre (per axle-mile) (in lire)	0.80 (1.29)	0.83 (1.34)	0.93 (1.50)
Receipts from waterways (in thousands of lire)	19 862	21 514	13 412
Various receipts (in thousands of lire)	181 111	199 766	188 467
Total receipts (in thousands of lire)	3 480 297	4 302 056	5 067 419
Ordinary expenditure (in thousands of lire)	3 407 266	3 617 377	4 066 493
On staff (in thousands of lire)	1 578 030	2 123 000 (1)	2 372 000 (1)
Various (in thousands of lire)	1 829 236	1 494 000 (1)	1 695 000 (1)

(1) Round figures.

Financial results (continued) :	1923-1924	1924-1925	1925-1926
Supplementary expenditure (in thousands of lire).	338 017	472 555	603 266
Waterways, expenditure on (in thousands of lire).	33 158	36 332	19 534
Total expenditure (in thousands of lire) . . .	3 778 440	4 126 265	4 689 294
per kilometre (per mile) of line operated (in lire)	... ...	231 706.30 (372 888.41)	259 470.29 (417 569.41)
per train-kilometre (per train-mile) (in lire) .	... ..	30.08 (48.41)	30.78 (49.53)
per axle-kilometre (per axle-mile) (in lire) . .	... ...	0.78 (1.26)	0.82 (1.32)
Balance (in thousands of lire).	298 143	175 791	378 125
Coefficient of operation (per cent)	102.91	88.90	85.01
Operating staff :			
Total number.	173 068	174 608	171 937
per kilometre (per mile) of line	10.99 (17.67)	10.57 (17.01)	10.41 (16.75)
Accidents :			
Passengers killed	23	40	51
Passengers hurt	886	1 208	1 102
Employees killed.	61	80	80
Employees hurt	533	537	544
Third parties killed	196	245	257
Third parties hurt	258	304	344

In 1925-1926 the length of line operated increased from 15 760 to 15 771 km. (from 9 793 to 9 800 miles) in the case of standard gauge lines: and remained unchanged at 726 km. (451 miles) in the case of the narrow gauge.

The length of double track increased from 3 706 to 3 722 km. (from 2 303 to 2 313 miles), and the electrified lines from 855 to 914 km. (from 531 to 568 miles).

On the 1 January 1926, navigation with the islands was conceded to private companies.

The passenger traffic shews an increase of about 6 %, due in the greater part to the many pilgrimages which were made during the first half of the year.

The goods traffic, on the other hand, only shewed an increase of 2.71 % on the tonnage handled and of 5.27 % on the ton-kilometres moved.

The journeys worked by electric traction increased from 11 to 13 million train-kilometres (6.835 to 8.078 million train-miles).

During the year 1924-1925 the considerable increase in the traffic, and the difficulties due to the winter season, made it necessary to increase for a certain time the operating staff (from 176 000 to 178 000). In 1925-1926 it was possible to reduce the number of employees gradually and to bring the establishment down to a figure below that of the preceding year (178 000 to 173 000).

The available rolling stock which, not without difficulty, had been sufficient for the 1924-1925 traffic had been sensibly further reduced in 1925-1926 : in fact, on the one hand, it had been necessary to break up and withdraw a number of vehicles no longer worth repairing and, on the other, it had not been possible to replace them by new stock. By suitable methods, the administration had, none the less, been able to meet the needs of the traffic in 1925-1926, but the difficulties experienced brought to notice the absolute necessity for increasing the stock. At the present time large orders for rolling stock have been placed.

As a result of the alteration in the tariffs put in force in April and May 1925, and of the increase in traffic, the traffic receipts for 1925-1926 shew an appreciable growth over those of the preceding year (from 4 302 to 5 067 millions).

The total expenditure shewed an increase of 563 millions (4 126 millions to 4 689) which in less than the increase in receipts, so that the balance has improved from 176 millions for the year 1924-1925 to 378 millions in 1925-1926.

The administration has also made considerable efforts to increase the traffic; thus, in 1925-1926 the average mean daily haul (time-table) has been raised from 203 000 to 224 000 km. (126 000 to 139 000 miles), and the total annual haul of passenger trains from 70 to 77 million kilometres (43.50 to 47.85 million miles). It has thereby, it may be said, again reached the pre-war traffic density.

NEW BOOKS AND PUBLICATIONS

[385. (09.3 (.494)]

WELTI (Dr. A.). — **25 Jahre Schweizerische Bundesbahnen (1902-1927)** [**25 years of the Swiss Federal Railways (1902-1927)**]. — One volume 8vo (6 3/4 × 9 1/2 inches) of 113 pages, with 63 figures and 2 plates (photographs) at the end of the book, and 7 plates (map, diagrams, etc.) in the text. — 1927, Zurich and Leipzig, Orell Füssli Verlag.

The author of this book disclaims any wish to write the history of the Swiss Federal Railways, which he leaves to railwaymen and, in particular, to the First President of the General Management, Pl. Weissenbach, who wrote *Das Eisenbahnwesen der Schweiz* (1).

The object of the book has been simply to raise a sort of monument to mark a date, that of the beginning of a large State undertaking. The new era he has studied really started in 1902, the year in which three of the five large systems affected by the law for the repurchase of the railways passed into the hands of the Federal Administration. The fusion was only completed in 1913 by the final transfer of the Saint Gothard line.

The author in his book set himself the task of bringing out clearly the results obtained by the Federal Administration during the twenty-five years that have passed since it was decided to amalgamate the Swiss railways.

The book is divided into three parts dealing with three distinct periods : the first includes the principal events which occurred from 1902 to 1913 during the building up of the system; the second, the years of the war, and the third, the operation of the lines during the years that have passed since the termination of hostilities.

The transfer of the private undertakings to the control of the Federal Administration necessitated a very considerable amount of reorganisation work. It was followed shortly after by reduction of rates and by better railway communications, and subsequently thereto by improvements in the rolling stock and permanent way. The reader can note during this period the extension of the system by incorporating existing lines, by building new lines and by inaugurating new water transport services. During the same period the Administration improved the conditions of service of the staff, and reorganised the superannuation, benevolent and sickness funds. The number of accidents was reduced. After one critical year (1908) the operating results improved, and the years 1909 to 1913 ended with large excess receipts. The first twelve years were completed in an atmosphere of satisfaction and of confidence in the new regime.

The war years caused a falling off of traffic which, with the reduction of receipts, made it necessary to take special measures : no new works and fewer trains. After this followed the many increases in rates. The goods traffic was handled with difficulty owing to lack of stock. Without the unified control that had been built up, the author thinks that the Swiss railways could not have met the situation with so much success.

The third part is interesting on several accounts, but above all, for the informa-

(1) A review of this work was published in the July-September 1919 number (English edition) of the *Bulletin of the Railway Congress*.

tion given therein on the beginning and development of the electrification of the Swiss railways. Another important chapter is that which gives the reorganisation of the Federal Administration. A further chapter deals with a subject of present interest for many of the railway systems : the competition of road transport.

When the difficulties which confronted the Federal Administration, and the remarkable results which have crowned its efforts are considered, we must share the feeling of the author about the success of the great undertaking of the repurchase of the railways, and the devotion, scientific knowledge, and clear vision of the men who assumed the task of carrying it through to success.

E. M.

[385. (09.1 (.45)]

CORINI (Felice), Engineer. — **Problemi ferroviari italiani. — Costruzioni, elettrificazioni, esercizio (Railway problems in Italy. – Construction, electrification and operation.)** — One volume in-octavo (8 3/4 × 6 1/4 inches) of 166 pages. — 1927 — Parma, Tipografie Riunite Donati.

The author in this book deals with the problems he considers the most important of those presenting themselves at the present time to the Railway Companies and especially in Italy.

The first chapter contains a concise review of the facts that lead up to the present organisation of the Italian system which, at the present time, extends to a length of about 20 000 km. (12 500 miles) of which 4 000 km. (2 500 miles) are conceded to private companies, so that there are 6.1 km. per 100 km² (about 10 miles per 100 square miles) of territory.

The second chapter considers projected construction of new lines : both those having an international character, those intended to give improved connections with maritime ports and those of a local character.

These two chapters make up the first part entitled « Construction ».

It will be appreciated that for an Italian author the question of electrification would be a matter of special interest, and this forms the subject of the second part of the work. Mr. Corini considers it both from the financial point of view and from that of national safety, and discusses the choice of the system. He formulates conclusions which are pleasing by their clearness and precision. From the financial point of view the too simple idea which considers electrification as shewing advantages in the case of railways in hilly country and as not being suitable for railways in flat country must be brushed aside. The volume of traffic is the deciding factor. It is desirable to retain steam traction or to adopt electric traction according as to whether the traffic expressed in virtual ton-kilometres in relation to the actual length is below or above a certain figure. This figure depends, furthermore, upon the cost of coal, the price of electric energy, the respective consumptions of coal and of electricity per virtual ton-kilometre, and upon the expenditure to be incurred with electric traction expressed per kilometre of track. Under the conditions laid down, taken from the results obtained in Italy, Mr. Corini shews that for a traffic of 3 000 000 virtual ton-kilometres per kilometre of line from the point of view of economy, it is a matter of indifference whether the line is worked by steam or electric traction.

The systems of electric traction are considered from the point of view of the motors used and from that of the fixed plant, and here again we find precise

conclusions we feel should be summarised :

Alternating three-phase current is the best for trains travelling long distances without frequent stops over lines with heavy gradients on which the amount of energy regenerated is important;

Continuous current and monophase alternating current are most suitable for railways on which, owing to the easy gradients, regeneration is of little practical importance;

Of these latter systems, continuous current at high tension (1 500 to 3 000 volts) is to be preferred on lines with heavy traffic, and conversely, monophase alternating current is better when the traffic is limited.

Chapter III of this second part contains many interesting figures on the results obtained with electric traction in Italy. The next chapter describes and discusses projected schemes being carried out or being considered at the present time.

It should be noted here that various considerations, amongst which the necessity of not having a number of systems on one railway, have led the author to come to a conclusion unfavourable to the application of three-phase alternating current at the industrial frequency to electric traction [1].

The third part — Operating — contains eight chapters.

The first discusses the question of operating by private companies or by the State and gives a historical review of the question in Italy. The second describes the organisation of the Italian State Railways.

In the two following chapters the author analyses the progress achieved in protecting trains during shunting in the stations and when running over the lines.

The fitting of the automatic brake to merchandise stock is considered from several points of view : safe working, economy, capacity of the railways, and the technical difficulties of fitting it.

In chapter VI, Mr. Corini discusses the efficiency of steam locomotives and the possibility of applying the turbine or internal combustion motor to locomotives. He sees in the future the railways with heavy traffic operating with electric traction : those with lighter traffic but having heavy express trains using high pressure steam turbines with condensing gear, and the light railways using internal combustion motors on the Schneider principle (direct transmission of part of the power of the Diesel motor, and indirect transmission of the remainder).

Chapter VII gives an interesting discussion on what should be the general rates policy. A supplement to his chapter at the end of the book gives the cost price of the different traffics during the year 1925-1926 : cost of the passenger train-kilometre and axle-kilometre, cost of the passenger-kilometre for the three classes, cost of the merchandise train-kilometre and axle-kilometre, cost of the merchandise ton-kilometre, and of the product per passenger-kilometre of the three classes and the product per ton-kilometre of merchandise.

How the methods of transport recently extensively developed compete with the railways, such as the automobile and flying machine, are characterised by Mr. Corini, and the role he assigns them will be read with interest. The field remaining open to the railway is still very great.

E. M.

(1) See article by the same author on this question in the *Bulletin of the Railway Congress*, July 1927, p. 563.